

# **Performance of Cochlear Implant Patients Using Bimodal Stimulation and FM System**

**Thesis**

*Submitted for Partial Fulfillment of Master Degree  
in Audiology*

**By**

**Rasha Abdulla Mohammed**

M.B.B.Ch.,

**Under Supervision of**

**Prof. Dr. Adel Ibrahim Abdel Maksoud**

*Professor of Audiology and Head of Audiology unit,  
ENT Department  
Faculty of Medicine- Ain-Shams University*

**Dr. Rasha Hamdy Elkabarity**

*Assistant Professor of Audiology, ENT Department  
Faculty of Medicine- Ain Shams University*

**Dr. Tayseer Taha Abdel Rahman**

*Assistant Professor of Audiology, ENT Department  
Faculty of Medicine- Ain Shams University*

*Faculty of Medicine  
Ain Shams University*

2018



*First of all, thanks to God to whom I relate any success in achieving any work in my life.*

*I would like to express my deepest gratitude and appreciation to **Prof. Dr. Adel Abdel Maksoud**, professor of Audiology and Head of Audiology Unit, Ain shams University for his sincere guidance, valuable advice and constructive remarks that added a lot to this work.*

*I offer my warmest thanks to **Dr. Rasha Hamdy Elkabarity**, Assistant Professor of Audiology, Ain shams University for her careful supervision, kind guidance and great help.*

*I am greatly indebted to **Dr. Tayseer Taha Abdel Rahman**, Assistant Professor of Audiology, Ain shams University, who in addition to her valuable guidance, has provided me with a great deal of support, encouragement and knowledge.*

*For my family, no word can express my feelings towards them, they are doing a lot for me. My particular appreciation to **my mother** and **my husband** for their care, help and encouragement throughout this work.*

***Rasha Abdulla***

# List of Contents

<b>Subject</b>	<b>Page No.</b>
<b>List of Abbreviations .....</b>	<b>I</b>
<b>List of Tables .....</b>	<b>III</b>
<b>List of Figure .....</b>	<b>VI</b>
<b>Introduction and Rationale.....</b>	<b>1</b>
<b>Aims of the Work.....</b>	<b>4</b>
<b>Review of Literature</b>	
<b>Chapter (1): Cochlear Implant .....</b>	<b>5</b>
<b>Chapter (2): Binaural Hearing.....</b>	<b>26</b>
<b>Chapter (3): Temporal Processing in CI Recipients .....</b>	<b>38</b>
<b>Chapter (4): Frequency Modulation (FM) system</b>	
with cochlear implantation .....	<b>49</b>
<b>Materials and Methods.....</b>	<b>62</b>
<b>Results .....</b>	<b>75</b>
<b>Discussion.....</b>	<b>101</b>
<b>Conclusion .....</b>	<b>112</b>
<b>Recommendations .....</b>	<b>113</b>
<b>Summary.....</b>	<b>114</b>
<b>References .....</b>	<b>116</b>
<b>Appendices.....</b>	<b>158</b>
<b>Arabic Summary .....</b>	<b>—</b>

## List of Abbreviations

<b>Abb.</b>	<b>Full term</b>
<b>AB</b>	Attentional blink
<b>AFG</b>	Auditory figure ground
<b>AFT-R</b>	Auditory fusion test revised
<b>APHAB</b>	Abbreviated Profile of Hearing Aid Benefit
<b>AV</b>	Aversiveness
<b>BMS</b>	Bimodal stimulation
<b>BN</b>	Background noise
<b>CANS</b>	Central auditory nervous system
<b>CI</b>	Cochlear implantation
<b>DAI</b>	Direct audio input
<b>DPS</b>	Duration pattern sequence
<b>DS%</b>	Discrimination score
<b>EC</b>	Ease of communication
<b>ERPs</b>	Event-related evoked potentials
<b>F0</b>	Fundamental frequency
<b>FM</b>	Frequency modulation
<b>HAs</b>	Hearing aids
<b>HF</b>	High frequency
<b>HINT</b>	Hearing in noise test
<b>HL</b>	Hearing loss
<b>IDR</b>	Input dynamic range
<b>ILD</b>	Inter aural level difference
<b>IPI</b>	Inter pulse interval
<b>IT- MIAS</b>	Infant Toddler Meaningful Auditory Integration score
<b>ITD</b>	Inter aural time difference
<b>LF</b>	Low frequency

<b>Abb.</b>	<b>Full term</b>
<b>LTASS</b>	Long term average speech spectrum
<b>MCL</b>	Most comfortable level
<b>NH</b>	Normal hearing
<b>PBKG</b>	Phonetically balanced kindergarten
<b>PDT</b>	Pitch discrimination test
<b>PPST</b>	Pitch pattern sequence test
<b>RV</b>	Reverberation
<b>SD</b>	Standard deviation
<b>Sig,</b>	Significance
<b>SNHL</b>	Sensorineural hearing loss
<b>SNR</b>	Signal to noise ratio
<b>SQ</b>	Squelch
<b>SRT</b>	Speech recognition threshold
<b>TFS</b>	Temporal fine structure

# List of Tables

Table	Title	Page
<b>1</b>	Demographic data of hearing loss in group I with prelingual HL (n= 19)	75
<b>2</b>	Aetiology of hearing loss in group I (pre-lingual HL)	76
<b>3</b>	Demographic data of hearing loss in group II (n=9)	77
<b>4</b>	Aetiology of hearing loss in group II (postlingual HL)	78
<b>5</b>	Mean, Standard Deviation(SD) and Range of CI aided warble tones thresholds in both groups (n=19)	79
<b>6</b>	Mean, Standard Deviation(SD) and Range of speech reception threshold (SRT), speech discrimination scores (DS%) in quiet and in noise by CI in both groups	80
<b>7</b>	Mean, Standard Deviation(SD) and Range of pitch discrimination test (PDT) and pitch pattern sequence test (PPS) scores by CI in both groups	81
<b>8</b>	Mean, Standard Deviation (SD) and Range of Auditory fusion test (AFT) scores in (Msec.) by CI in both groups	81
<b>9</b>	Mean, Standard Deviation(SD) and Range of MAIS questionnaire scores in group I (n=19)	82
<b>10</b>	Mean, Standard Deviation(SD) and Range of APHAB questionnaire scores in group II (n=9)	83

<b>Table</b>	<b>Title</b>	<b>Page</b>
<b>11</b>	Correlation between CI outcome and demographic data in group I with prelingual HL (n=19)	85
<b>12</b>	Correlation between CI outcome and demographic data in group II with postlingual HL (n=9)	86
<b>13</b>	Correlation between CI outcome and MAIS questionnaire in group I with prelingual HL	87
<b>14</b>	Correlation between CI outcome and APHAB questionnaire global scores in group II with postlingual HL	88
<b>15</b>	Mean and standard deviation (SD) of unaided, aided thresholds of the non implanted ear, CI aided thresholds and bimodal aided thresholds in group I (n=19)	89
<b>16</b>	Mean and standard deviation (SD) of unaided, aided thresholds of the non implanted ear, CI aided thresholds and bimodal aided thresholds in group II (n=9)	91
<b>17</b>	Comparison between the three conditions (CI alone, BMS and BMS with FM) according to the speech discrimination scores in quiet and in noise in group I (n=19)	93
<b>18</b>	Comparison between the three conditions (CI alone, BMS and BMS with FM) according to the pitch discrimination, pitch pattern sequence and auditory fusion test scores in group I (n=19)	95

<b>Table</b>	<b>Title</b>	<b>Page</b>
<b>19</b>	Comparison between the three conditions (CI alone, BMS and BMS with FM) according to the speech discrimination scores in quiet and in noise in group II (n=9)	96
<b>20</b>	Comparison between the three conditions (CI alone, BMS and BMS with FM) according to the pitch discrimination, pitch pattern sequence and auditory fusion test scores in group II (n=9)	98
<b>21</b>	Correlation between aided and unaided thresholds in the contralateral non implanted ear and speech perception in quiet and in noise, pitch pattern sequence test and auditory fusion test using CI and contralateral HA in group I and group II	99



# List of Figures

<b>Figure</b>	<b>Title</b>	<b>Page</b>
<b>1</b>	Components of cochlear implant system	7
<b>2</b>	Types of electrode coupling	11
<b>3</b>	Schematic presentation of how CI works	13
<b>4</b>	Hybrid mechanism	33
<b>5</b>	Lapel microphone	51
<b>6</b>	Lavalier microphone	51
<b>7</b>	Boom microphone	51
<b>8</b>	Pass-Around microphone	52
<b>9</b>	Sound field system	52
<b>10</b>	Microlink touch screen transmitter	64
<b>11</b>	Microlink freedom battery cover	64
<b>12</b>	Roger X receiver	65
<b>13</b>	FM battery pack cover	65
<b>14</b>	Aetiology of hearing loss in group I	76
<b>15</b>	Aetiology of hearing loss in group II	78
<b>16</b>	The mean of CI aided warble tones thresholds in both groups	79
<b>17</b>	The mean score of SRT, speech discrimination (DS%) in quiet and in noise by CI in both groups	80
<b>18</b>	The mean score of Arabic APHAB questionnaire in group II	84
<b>19</b>	The mean of unaided, aided thresholds in the contralateral non implanted ear, CI aided thresholds and bimodal aided thresholds by CI and contralateral HA in group I	90

<b>Figure</b>	<b>Title</b>	<b>Page</b>
<b>20</b>	The mean of unaided, aided thresholds in the contralateral non implanted ear, CI aided thresholds and bimodal aided thresholds by CI and contralateral HA in group II	92
<b>21</b>	Comparison between the three conditions (CI alone, BMS and BMS with FM) according to the speech discrimination scores in quiet and in noise in group I	94
<b>22</b>	Comparison between the three conditions (CI alone, BMS and BMS with FM) according to the speech discrimination scores in quiet and in noise in group II	97



---

# Introduction

---





---

# Aims of the Work

---





---

# Chapter (1)

## **Cochlear Implant**

---





---

## Chapter (2)

# **Binaural Hearing**

---





---

# Chapter (3)

## **Temporal Processing in CI Recipients**

---

