Role of Video Head Impulse Test In Evaluating Patients With Unilateral And Bilateral Caloric Weakness

Thesis submitted for partial fulfillment of the M.sc of Audiology Submitted By: Dr./ **Mohammed Hany El-Hakeem**

Supervised by

Prof. Dr./ Somia Tawfik

Professor of Audiology, ENT Department Faculty of Medicine, Ain Shams University

Prof. Dr./ Dalia Mohamed Hassan

Professor of Audiology, ENT Department Faculty of Medicine, Ain Shams University

Faculty of Medicine – Ain Shams University 2018

بلية المجالخي



طه _ ۱۱٤

Acknowledgement

First and foremost, I attribute endless thanks to God -the most gracious, most merciful- for granting me the ability to continue and complete this research. Hoping to God that we have followed his light and guidance through this work, and may we continue to do so.

I would like to thank **Prof. Dr./ Somia Tawfik**, Professor of Audiology, Ain Shams University who gave me access to research facilities and equipment. Her expert comments and opinions helped shape this work. I would also like to thank her for giving me the capacity to express my own views, and having the patience to listen to what I had in mind.

I would like to express gratitude to **Prof. Dr./ Dalia Mohamed**, Professor of Audiology, Ain Shams University, for her constant support, motivation, and encouragement throughout the entirety of this research. Wishing her the best health, and hoping that other candidates would have the same blessing of having her as a supervisor.

I would like to thank all the individuals who participated in the study.

Last but certainly not least, I have to thank my dear Father and Brother for motivating me during this work, and their presence that lights my life, and pushes me forwards.

Mohammed Hany El-Hakeem 2018

Table of Contents

A.)	List of Tables	6
B.)	List of Figures	14
C.)	List of Abbreviations	20
D.)	Introduction and Rationale	23
	Aim of the Work	27
E.)	Review of Literature	
C	Chapter 1: Testing The Vestibulo-ocular Reflex	
	The VOR:	
	Neurophysiology	29
	VOR and Frequency	30
	Cervico-ocular and Optokinetic Reflexes	33
	VOR Testing Modalities:	
	Testing Frequency And The Vestibular Response	34
	Low Frequency Tests	36
	High Frequency Tests	

Chapter 2: Disorders Affecting VOR	
Unilateral VOR Lesions	
Bilateral VOR Lesions	
Prognosis of A Deficient VOR	61
Chapter 3: Video Head Impulse	
History and Premise	65
Equipment	66
vHIT Output	68
vHIT Indications and Validity	76
F.) Methodology	83
G.) Results	108
H.) Discussion	178
I.) Summary	209
J.) Conclusions	213
K.) Recommendations	215
K.) References	217
L.) Arabic Summary	

List of Tables

**	Table (1): Age and Gender Distribution of Study Group 1, Study Group 2,
	and Control Group:
*	Table (2): Medical History Study Group 1, and Study Group 2: 83
.	Table (3): Caloric Test Results84
*	Table (4): Classification of Study Group 1 into Subgroups According to the degree of Caloric Asymmetry (Subgroup and the Range of Caloric Test Results, Number, Percentage, Mean Caloric Asymmetry of the subgroup
	(\bar{X}) , and SD)
*	Table (5): Caloric Tests Results of Study Group 2 85
.	(6): Comparison between the Head Amplitudes in Study Group 1 and the Control Group:
*	Table (7): Comparison between the Right and Left Head Amplitudes in Study Group 1 and the Control Group:
.	Table (8): Comparison between the Head Amplitudes in Study Group 2 and the Control Group:

*	Table (9): Comparison between the Right and Left Head Amplitudes in
	Study Group 2:
*	Table (10): VOR Gain Mean (\overline{X}), Standard Deviation (\underline{SD}), Range, and the
	mean of the Standard Deviation of the 20 impulses/subject ($\underline{Variability}$) in
	the different canals of the Control Group:
*	Table (11): Difference between Gain values of the Right and Left
	Semicircular Canals in the Control Group: 89
*	Table (12): Frequency of saccade occurrence in Controls, and its side
	distribution90
*	Table (13): Number of Control subjects producing Covert Saccades, Overt
	Saccades, or impulses containing any type of saccade (overall)91
*	Table (14): Mean, SD, and Range of Covert and Overt Saccades
	Percentage, and t test between RT. & Lt. ears in different planes in the
	Control Group93
*	Table (15): Mean, SD , Range and t Test of Saccade Amplitude
	(degrees/second) in the different planes in the control group : 96
*	Table (16): showing the difference between the saccade amplitudes of the
	Right and Left ears 97

*	Table (17): Mean, SD and Range of Saccade Latency (time of occurrence
	after initial head movement in milliseconds) in the different test planes in
	the Control Group
*	Table (18): Correlation between Caloric Test results and vHIT Gain
	Asymmetry in the Control Group:99
*	Table (19): shows the Control Group's results with 68% Confidence
	Interval (Mean+/- 1SD), and 95% Confidence Interval (Mean +/- 2SD), as
	compared to the established norms and recommended cut-off values: 105
*	Table (20): Mean, SD, and Range of Gain in Study Group 1
*	Table (21): Comparison between Gain values of the <u>affected side</u> in Study
	Group 1, and the corresponding plane in the Control Group 106
.	Table (22): Comparison between different Subgroups regarding Gain data:
*	Table (23): Post-hoc analysis of the ANOVA test: 107
*	Table (24): Number and Percentage of Study Group 1 subjects producing
	Saccades 109
*	Table (25): Saccade Count of Study Group 1 in the different testing planes
	(covert count, overall count, number and percentage of
	subjects exhibiting such saccades, range, mean, standard deviation) 111

**	Table (26): Saccade Amplitude of Study Group 1 in the different testing
	planes (covert amplitude, overt amplitude, range, mean, and standard
	deviation)
*	Table (27): Saccade Latency of <u>Study Group 1</u> in the different testing
	planes (covert latency, overt latency, range, mean, and standard
	deviation)
.	Table (28): Comparison between Saccade findings in the affected side of
	Study Group 1 and the Control Group in the Lateral plane (Covert &
	Overt Count, Latency, Amplitude, Overall Count. Displayed as Mean, SD,
	t-value, and P-value)115
*	Table (29): Comparison between Saccade findings in the affected side of
	Study Group 1 and the Control Group in the Anterior plane (Covert &
	Overt Count, Latency, Amplitude, Overall Count. Displayed as Mean, SD,
	t-value, and P-value)116
.	Table (30): Comparison between Saccade findings in the affected side of
	Study Group 1 and the Control Group in the Posterior plane (Covert &
	Overt Count, Latency, Amplitude, Overall Count. Displayed as Mean, SD,
	t-value, and P-value)117
.	Table (31): comparison between different subgroups regarding saccade
-	data of the Lateral Canals (Right and Left sides grouped together to meet
	the minimum number required for a post-hoc analysis):
	me manufaction in the control of the post-not analysis).

*	Table (32): Post-hoc analysis of the ANOVA test: 118
*	Table (33): comparison between different subgroups regarding saccade data of the Anterior Canals
*	Table (34): comparison between different subgroups regarding saccade data of the Posterior Canals
*	Table (35): Post-hoc analysis of the ANOVA test: 120
*	Table (36): Correlation between Caloric Asymmetry and Gain results of the affected side (ipsilateral side)
*	Table (37): Correlation between Caloric Asymmetry and Gain values of the unaffected side (contralateral side):
*	Table (38): Correlation between Caloric Asymmetry and vHIT Asymmetry:
*	Table (39) Pearson's correlation between Caloric Asymmetry and vHIT asymmetry across the different subgroups:
*	Table (40): Correlation between degree of caloric asymmetry and saccades in the Lateral plane (percentage and amplitude):
*	Table (41): Correlation between degree of caloric asymmetry and saccades in the Anterior plane (percentage and amplitude):

*	Table (42): Correlation between degree of caloric asymmetry and saccades
	in the Posterior plane (percentage and amplitude):127
*	Table (43): Correlation between Caloric Asymmetry and Saccades (Mean Count, Mean Amplitude, and Maximum percentage across the 3 canals of the affected and unaffected sides
*	Table (44): Relation between Caloric Asymmetry and vHIT test outcome in Study Subgroup 1:
*	Table (45): Relation between Etiology and vHIT Test Outcome: 133
*	Table (46): Relation between Etiology and Gain and Saccade data of the Affected side
*	Table (47): Relationship between duration of the disease and overall vHIT outcome
*	Table (48): Correlation between disease Duration (in months) and the vHIT Outcome (+Ve or -Ve) in different degrees of Caloric Asymmetry:
.	Table (49): correlation between Duration of disease and Gain and saccade data of the Affected side
*	Table (50): Relationship between the nature of the Main Complaint and the overall vHIT outcome

*	Table (51): Relation between Complaint and vHIT Gain and Saccade data
	of the Affected side
*	Table (52): STUDY GROUP 2 descriptive Gain data:
*	Table (53): Comparison between Study Group 2 and Control Group as regards Gain data:
*	Table (54): Study Group 2 Saccadic Count in the different planes (covert count, overt percentage, number and percentage of subjects exhibiting them, range, mean, standard deviation):
*	Table (55): Study Group 2 Saccadic Latency in the different planes (covert latency, overt latency mean, standard deviation, range)
*	Table (56): Study Group 2 Saccadic Latency in the different planes (covert amplitude, overt amplitude mean, standard deviation, and range) 142
.	Table (57): shows the Sensitivity (Sn), Specificity (Sp) of the vHIT using The Caloric as the reference standard, in Study Group 1 and Control Group
*	Table (58): Shows the same calculations across the different subgroups of Study Group 1 with the Control Group
*	Table (59): vHIT outcome in Study Group 2, using the Caloric as the reference standard

List of Figures

**	Fig. (1) Illustrative diagram showing horizontal right head
	turn and the resultant VOR8
*	Fig. (2) Innervation from the Semicircular Canals through the Vestibular Nucleus to the Ocular Muscles
*	Fig. (3) Discharge regularity in vestibular-nerve afferents9
.	Fig. (4) Sinusoidal representation of the relationship between eye velocity and head velocity in VOR
*	Fig. (5) Vestibular Tests and their respective stimulus frequency
*	Fig. (6) Dominant gaze stabilizing mechanism at different head velocities
*	Fig (7) Illustrative diagram depicting the caloric position14
*	Fig (8) Figure showing the rise and fall of the caloric response, with the algorithm automatically identifying the peak response window –box–
*	Fig. (9) Computerized Clinical Rotatory Chair Test19
*	Fig. (10) Head Shake test with VNG goggles to abolish fixation

**	Fig. (11) Illustration of bedside head impulse test (bHIT),	
	with corrective saccade during left impulse	23
*	Fig. (12) Dynamic Visual Acuity Test	25
*	Fig. (13): Frequency ranges of gaze stabilization using COR, Pursuit, and VOR; against the required frequency during Daily Activities and Strenuous Activities	39
*	Fig. (14) ICS Impulse Goggles. 1. Unmovable Camera. 2. Gyroscope. 3. Nose Bride. 4. Laser Caliberator	41
*	Fig. (15) Interacoustics' EyeSeeCam vHIT. (1) Moveable Mounted Camera, (2) Reflection mirror, (3) Empty Socket for inserting the camera	42
*	Fig. (16) 2D Trace Analysis.	43
*	Fig. (17) 3D Traces: A. Is The Head Velocity Curve with a 'clipped' VOR, B. Shows Overt Corrective Saccades.	44
*	Fig. (18) Mean canal gain values displayed in a Hexplot	45
*	Fig. (19): Showing previously reported vHIT sensitivities and specificities across different etiologies, in study samples with different mean Caloric Deficits (CD).	50
*	FIG. (20) SUBJECT SEATING AND FIXATION DOT	60
*	FIG. (19) PUPIL DETECTION SCREEN	61

*	FIG. (20) LATERAL IMPULSES	62
*	FIG. (21): RECOMMENDED HORIZONTAL EYE POSITION DURING VERTICAL CANAL TESTING	64
*	FIG. (22) LARP IMPULSES	64
*	FIG. (23) COLLECTING ALGORITHM	65
*	FIG (25): VOR RESPONSE IDENTIFIED AS A SACCADE	67
*	FIG (26): THE REANALYSIS TOOL OF ICS IMPULSE SOFTWARE	68
*	FIG (24) A SINGLE HEAD IMPULSE AND ITS PARAMETERS	71
*	FIG. (25): AN EXAMPLE SHOWING THE OUTPUT AND VHIT REPORT FOR A PATIENT WITH UNILATERAL RIGHT CALORIC WEAKNESS	72
*	FIGURE (26): PIE-CHART REPRESENTATION OF PATIENTS' MAIN COMPLAINT	83
*	FIGURE (27): BAR CHAR OF ETIOLOGICAL DISTRIBUTION OF STUDY GROUP	84
*	FIGURE (28): PIE CHART OF NUMERIC DISTRIBUTION OF THE DIFFERENT SUBGROUPS	86
*	FIG. (29): BAR CHART OF NUMBER OF SUBJECTS PRODUCING THE DIFFERENT TYPES OF SACCADES IN THE CONTROL GROUP.	92