DEVELOPING CLINICAL DECISION SUPPORT SYSTEM FOR AUTOMATED DIAGNOSIS OF BPPV SUB TYPES:

USING ALGORITHMS FOR EVALUATION OF NYSTAGMUS AND TORSION

Kolkata 2019

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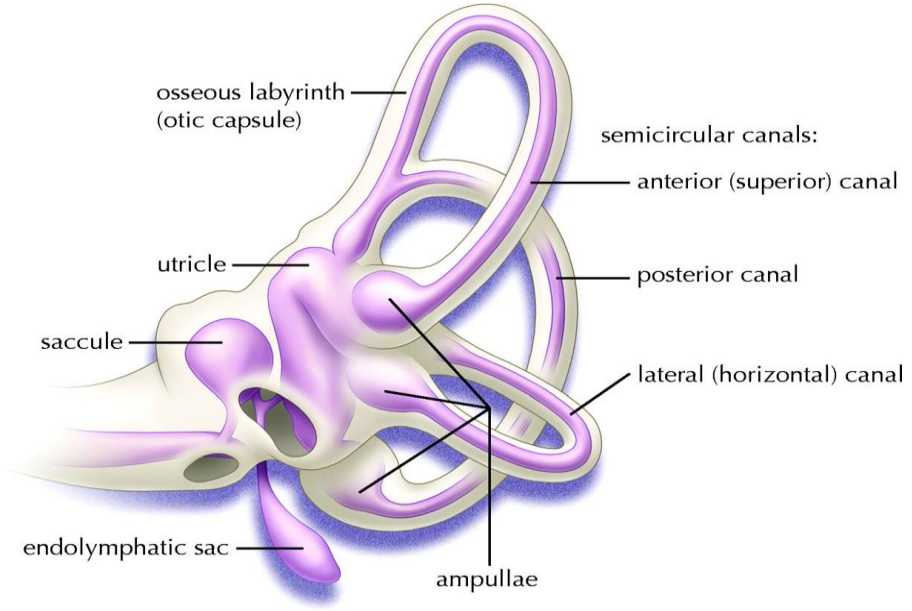
- Neurotologist
- M.S. (ENT)
- Fellowship in Otology and Neurotology (Singapore)
- Technical Advisor NeuroEquilibrium
- Development of equipment for diagnosis of vertigo and balance disorders

and devising rehabilitation protocols.

- Developing Virtual reality and Augmented reality based rehabilitation for patients of vertigo and phobia
- Granted 3 patents
- Applied for 6 patents

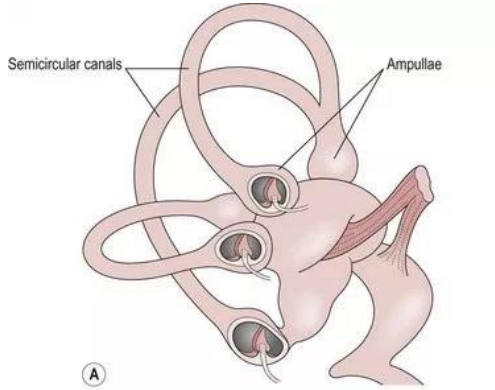
BPPV

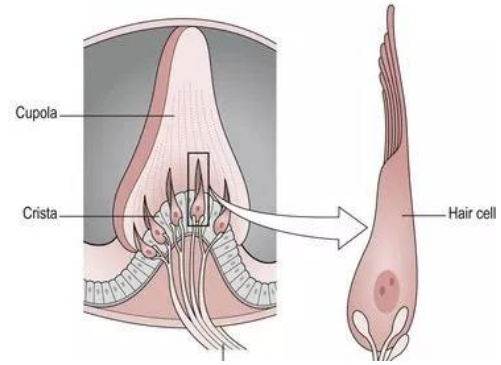


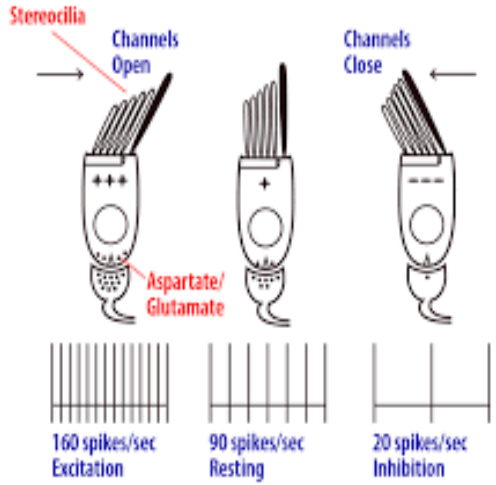
- Mechanical disorder
- Follows the laws of physics
- **Localization of the otoconia is deducted by**
  - **Gravitational orientation of semicircular canal**
  - **Vestibular physiology of the resulting nystagmus**
- Nystagmus SPV above 2º/sec is threshold for sensation of vertigo (Squires,Weidman 2004)

DETERMINATING FACTORS

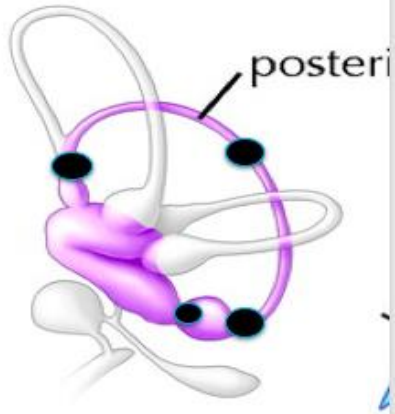
- Cupula placement will decide direction of maneuver
- Direction of nystagmus is dependent on orientation of kinocilium with respect to utricle
- Eyes move in the direction of the plane of the canal being stimulated (Ewald's Law)
- DBN – excitation of AC or inhibition of PC
- UBN – inhibition of AC or excitation of PC
- Ipsitorsion – excitation of down ear or inhibition of up ear







TYPES OF BPPV : POSTERIOR CANAL



Type	Position	Characteristics	Maneuver
Canalithiasis	Long Arm	• D-H going down: Upbeat nystagmus & geotropic torsion • Sitting: Reversal of nystagmus & torsion • Fatiguability/Duration: <1 min • Latency: few seconds	Epley / Semont's
	Short Arm	• D-H going down: No nystagmus/torsion • Sitting: Up beat nystagmus/torsion • Short Duration	Brisk Epley /QLRM
	Downbeat	• Downbeating nystagmus & apogeotropic torsion	Yacovino
Cupulolithiasis	Cupula or near cupula	• Up beating nystagmus & geotropic torsion • Brief/no latency: >1min • Non fatigable	Semont's

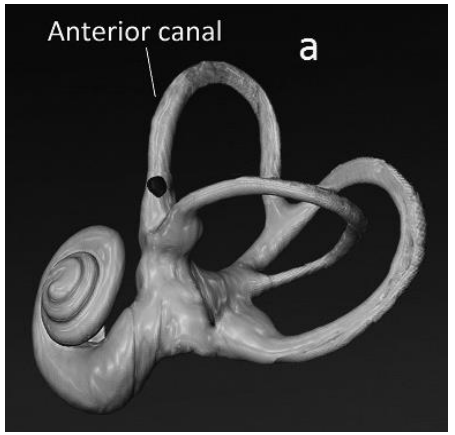
(Büki, Mandalà & Nuti, 2017)
(Califano, 2014)
(Von Brevern et al., 2015)

TYPES OF BPPV: HORIZONTAL CANAL BPPV

Type	Characteristics	Maneuver
Canalithiasis	• Geotropic Horizontal nystagmus • Stronger towards the affected ear	Barbeque/ Gufoni
Cupulolithiasis	• Apogeotropic Horizontal nystagmus • Weaker towards the affected ear	Barbeque/ Modified Gufoni
Light Cupula	• Direction changing geotropic nystagmus • Weaker towards unaffected side	No maneuver

(Büki, Mandalà & Nuti, 2014 , Kim et al., 2018)

ANTERIOR CANAL BPPV



Type	Characteristics	Maneuver

Canalithiasis / Cupulolithiasis	• Deep head hanging position
	• Downbeat nystagmus
	• Torsion
	  • Clockwise – Left AC
	  • Anticlockwise – Right AC
		Yacovino

(Büki, Mandalà & Nuti, 2017) (Califano , 2014)

PARAMETERS TO DIAGNOSE BPPV

- History
- Positional test with steps
- Nystagmus
  - Direction
  - Duration
  - Stronger/Weaker side
  - Latency
- Direction of torsion
- Any spontaneous nystagmus

SOFTWARE FOR TAKING HISTORY

1. When did the first episode of vertigo/dizziness occur

5 | Days

2. For how long did the first episode of vertigo/dizziness last

30 | Seconds

3. First Attack Type of Vertigo/Dizziness

Rotating/Spinning

4. When did the last episode of vertigo/dizziness occur

1 | Days

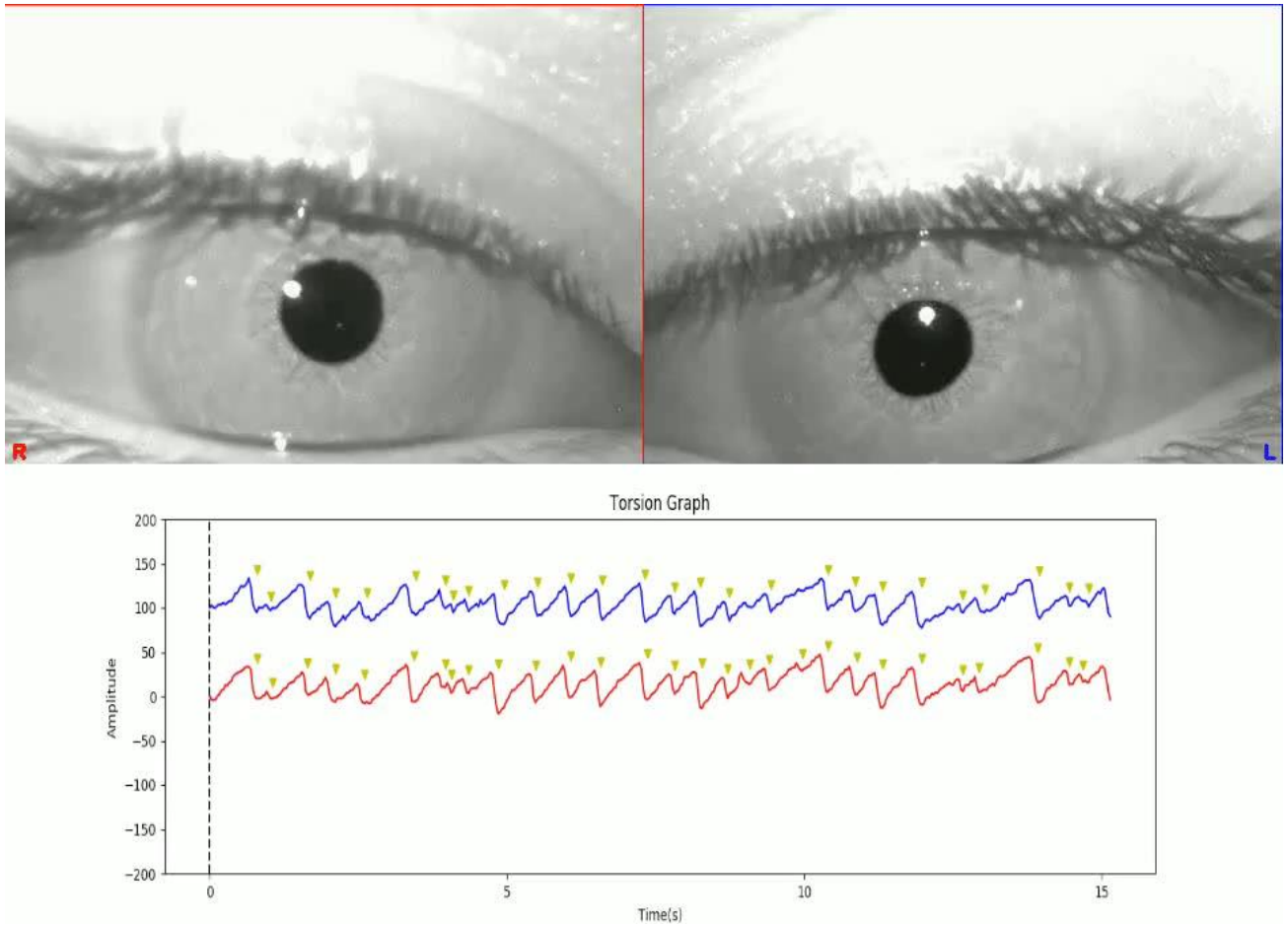
5. For how long did the last episode of vertigo/dizziness last

45 | Seconds

6. Last Episode Type of Vertigo/Dizziness

Rotating/Spinning

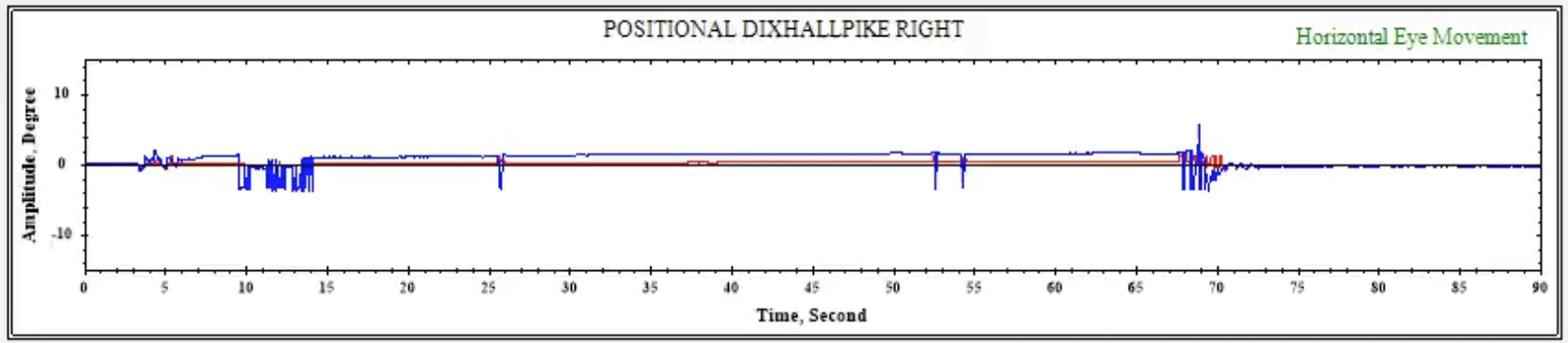
DETECTION OF TORSION – SPV & DIRECTION



NeuroEquilibrium Diagnostic Systems Pvt Ltd.

Info Test

Patient Name : *****	Patient ID : MEMAH19998	Date : 29-09-2018

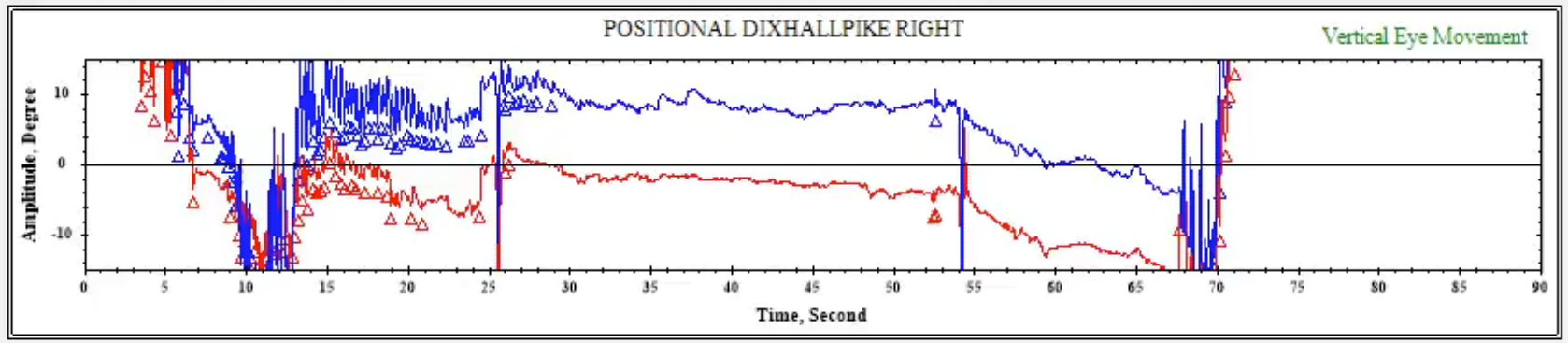


Remove Nystagmus

Left Side

Right Side

Remove All



Remove Nystagmus

Left Side

Right Side

Remove All

<< Previous Test

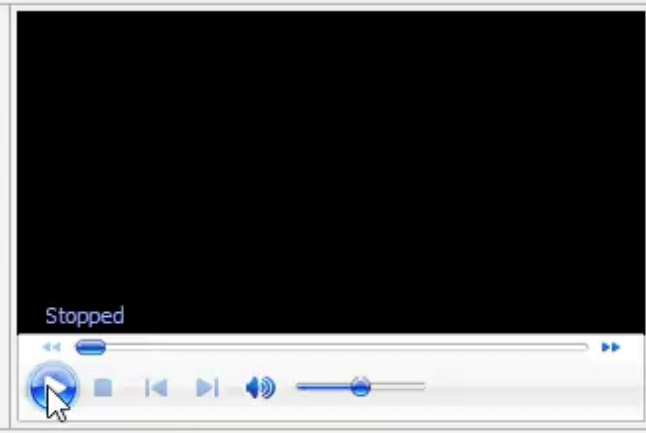
Skip To Next >>

Save & Continue

Fetch New Data

Reload Video

Exit



Graph Offest | Graph Scaling | Window Size | Nystagmus | Reset Values

Horizontal

Left -2.8

Right 0

Vertical

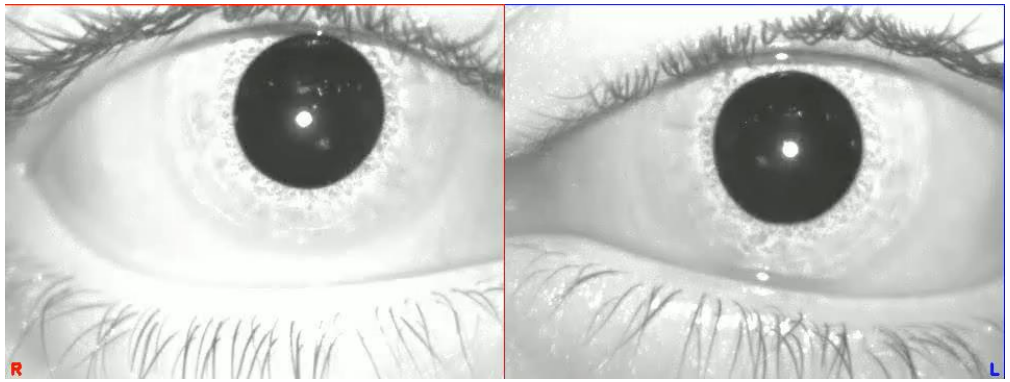
Left -33.3

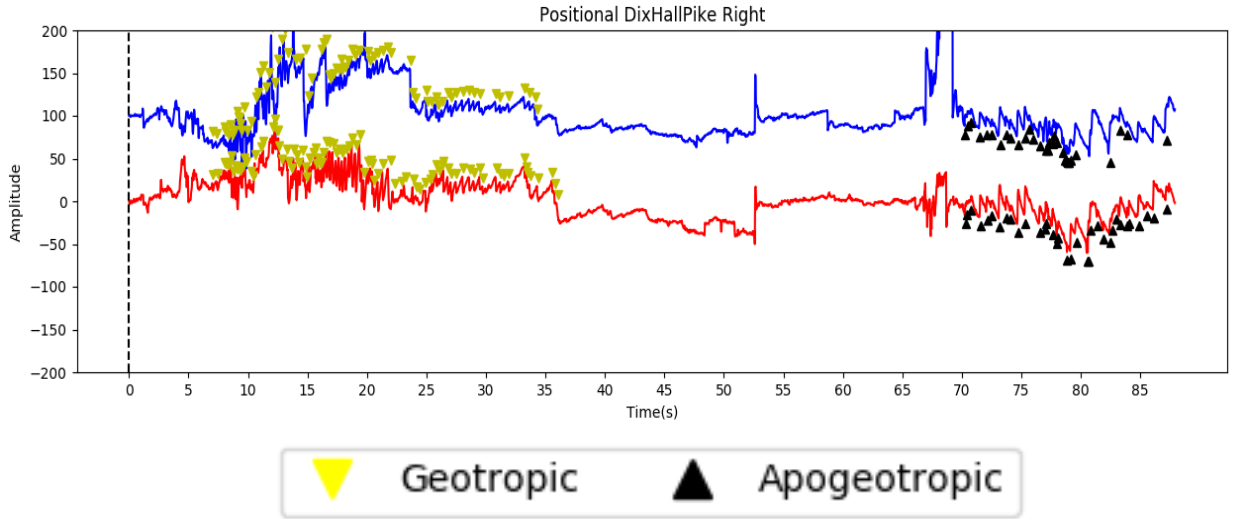
Right -27.7

POSTERIOR LONG ARM CANALITHIASIS

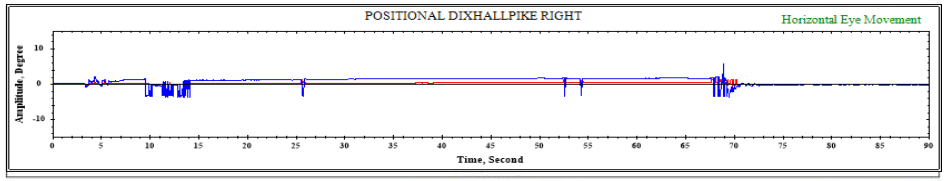
0

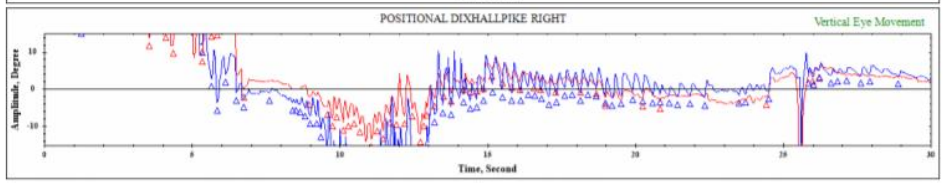
Right Dix Hallpike

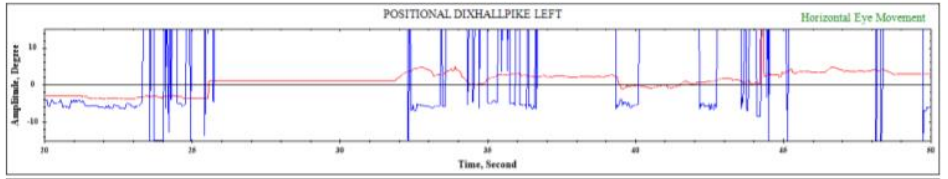


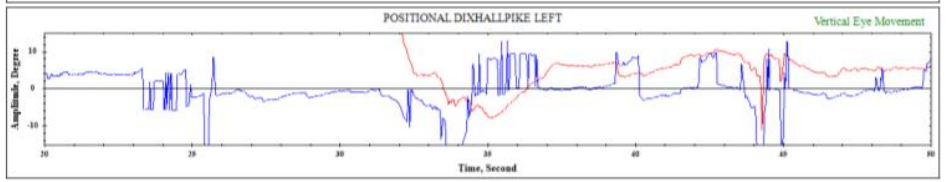


	Right Eye SPV(°/sec)	Right Eye Beats	Left Eye SPV(°/sec)	Left Eye Beats
Dix-Hallpike Right Horizontal	0	0	0	0
Dix-Hallpike Right Vertical	-32	69	-46	89
Dix-Hallpike Left Horizontal	0	0	0	0
Dix-Hallpike Left Vertical	0	0	0	0





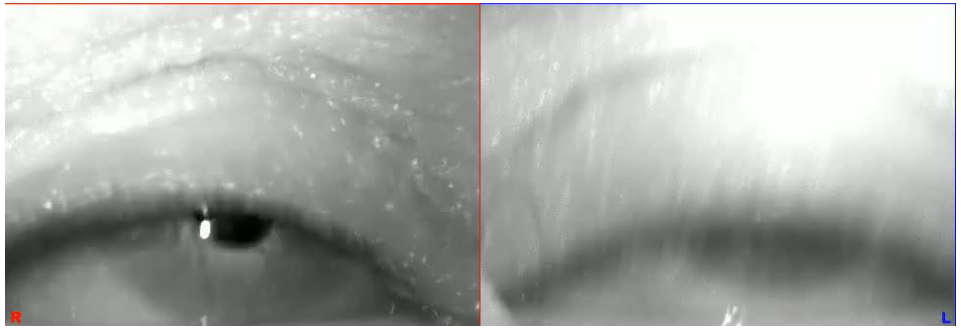




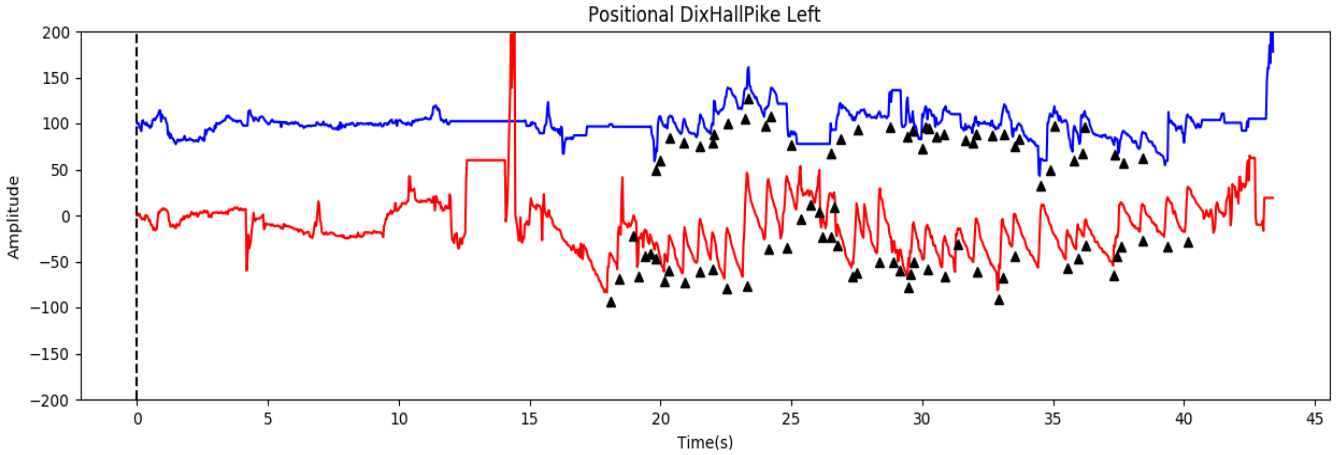
Torsion	Supine	Sitting
Direction	Geotropic	Apogeotropic
Beats /30sec	93	35

POSTERIOR SHORT ARM CANALITHIASIS

Left Dix Hallpike

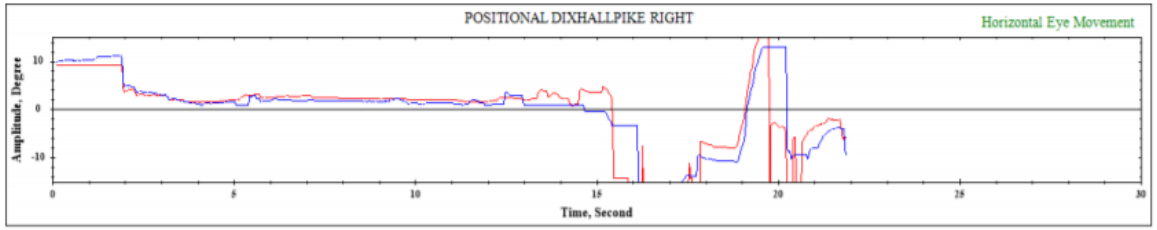


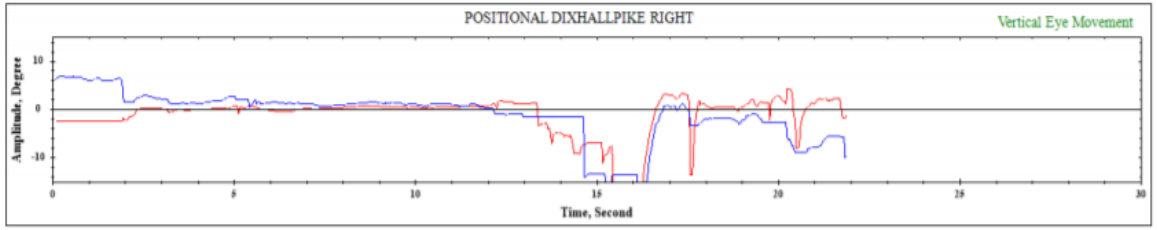
Torsion

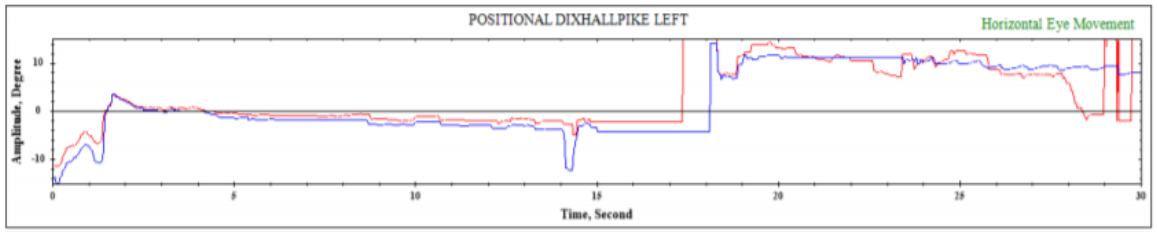


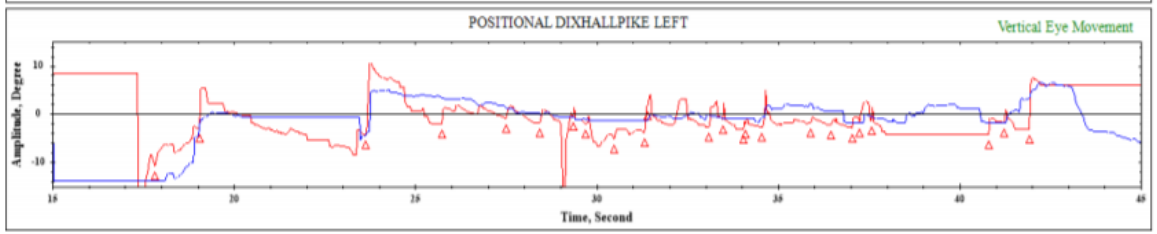
Beats /30 seconds: 47

	Right Eye SPV(°/sec)	Right Eye Beats	Left Eye SPV(°/sec)	Left Eye Beats
Dix-Hallpike Right Horizontal	0	0	0	0
Dix-Hallpike Right Vertical	0	0	0	0
Dix-Hallpike Left Horizontal	0	0	0	0
Dix-Hallpike Left Vertical	-10	27	0	0



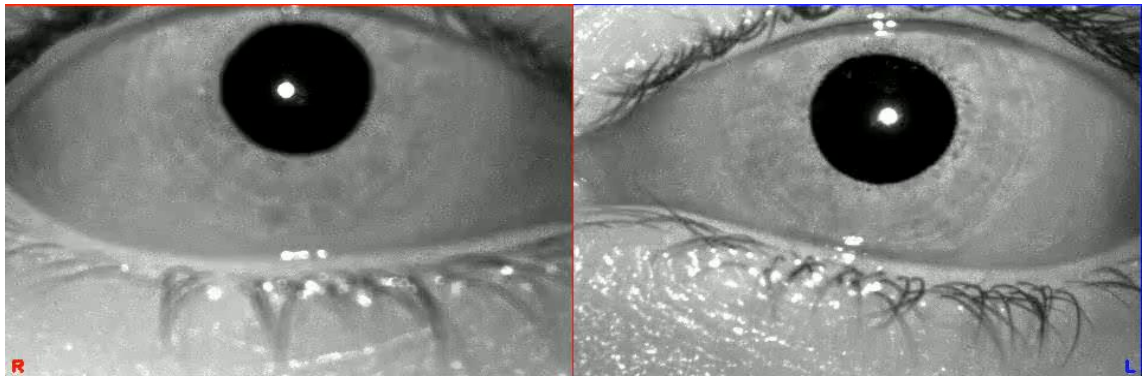




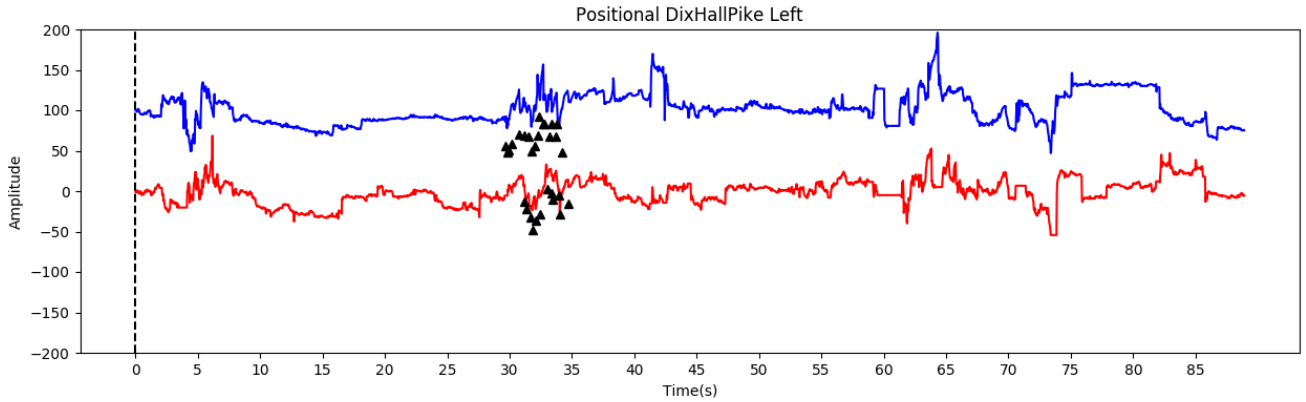


POSTERIOR SEMICIRCULAR CANAL DOWNBEATING

Left Dix Hallpike

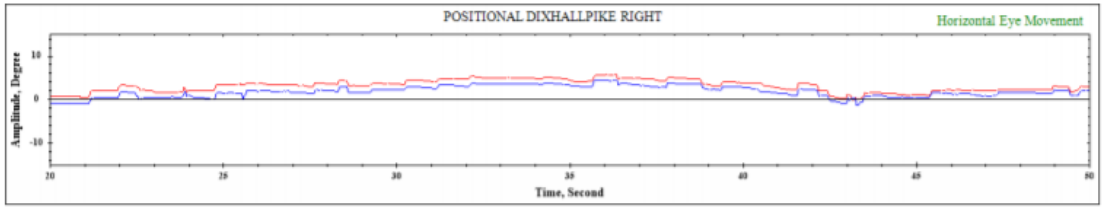


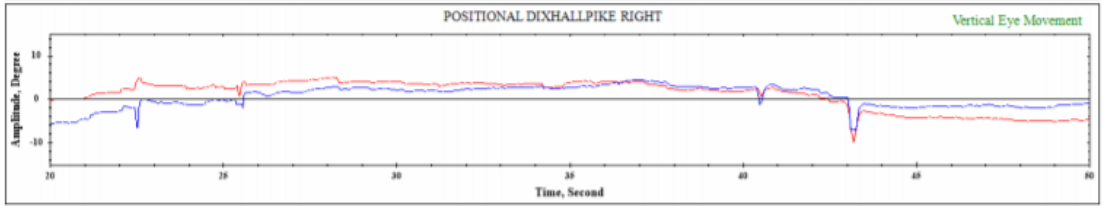
Torsion

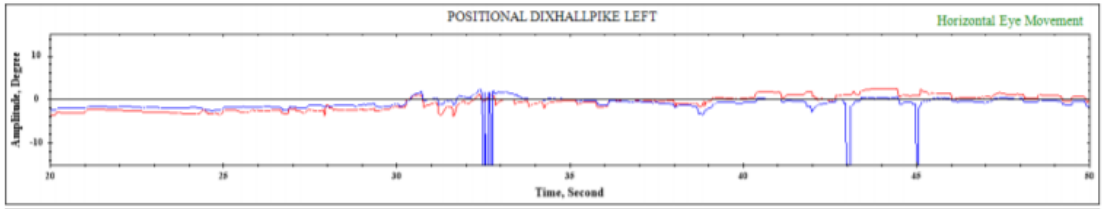


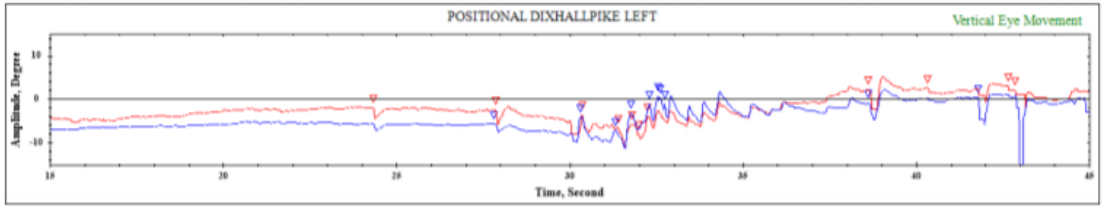
▲ Apogeotropic

	Right Eye SPV(°/sec)	Right Eye Beats	Left Eye SPV(°/sec)	Left Eye Beats
Dix-Hallpike Right Horizontal	0	0	0	0
Dix-Hallpike Right Vertical	0	0	0	0
Dix-Hallpike Left Horizontal	0	0	0	0
Dix-Hallpike Left Vertical	14	11	30	10









Direction: Apogeotropic

Beats /30 seconds: 12

CLASSIFICATION OF POSTERIOR CANAL DOWNBEATING BPPV (Califano)

1a: "Certain" APC

Presence of a down-beating paroxysmal nystagmus, torsional clockwise for the right canal and counterclockwise for the left canal, evoked through the Dix- Hallpike test and sometimes through the straight head hanging positioning.

Possible presence of a vertical down-beating component in the same positioning tests.

Canalar conversion in TPC during or immediately after (no more than 2 days) the therapeutic maneuver.

1b: “Probable" APC

As reported in 2a, but with a direct resolution of disease without canalar conversion in TPC.

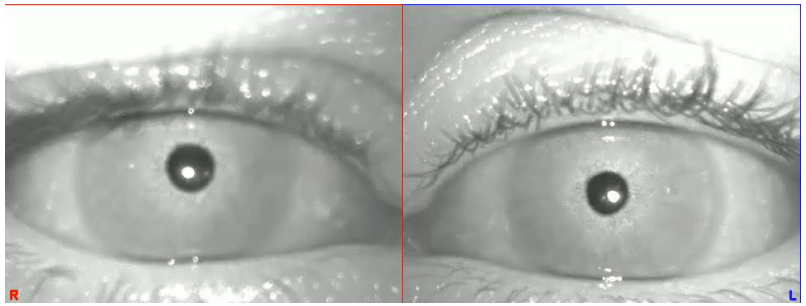
1c: “Possible" APC

Persistence of symptoms after five cycles of therapeutic maneuvres.

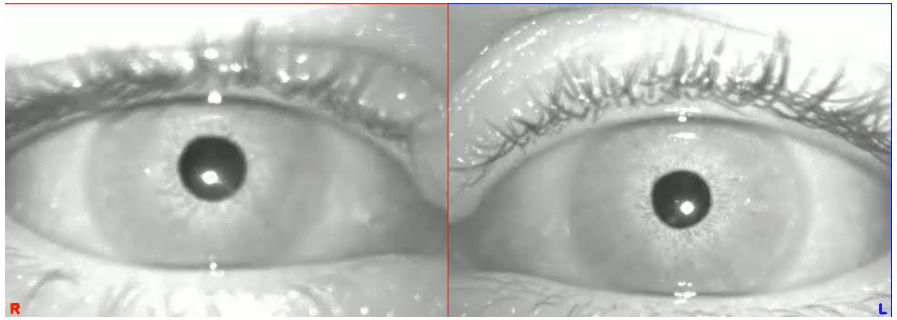
MRI does not show any neurological disease as a possible cause of nystagmus

HORIZONTAL – GEOTROPIC NYSTAGMUS

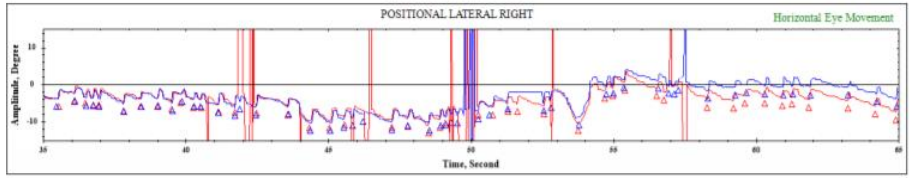
Lateral Right

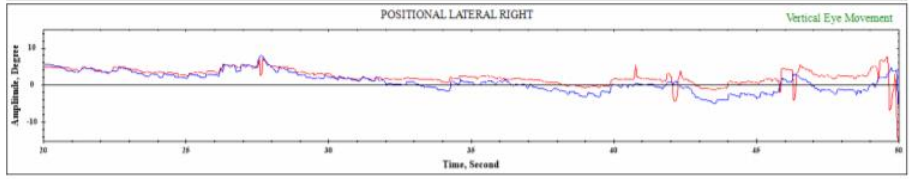


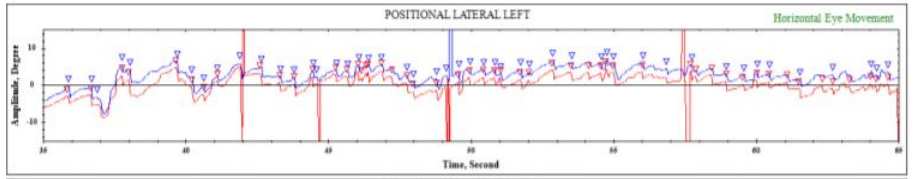
Lateral Left

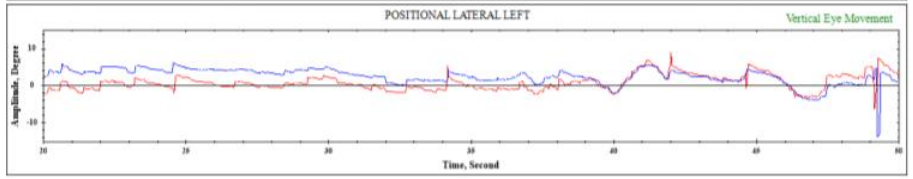


	Right Eye SPV(°/sec)	Right Eye Beats	Left Eye SPV(°/sec)	Left Eye Beats
Lateral Right Horizontal	-52	110	-25	118
Lateral Right Vertical	0	0	0	0
Lateral Left Horizontal	23	116	13	117
Lateral Left Vertical	0	0	0	0

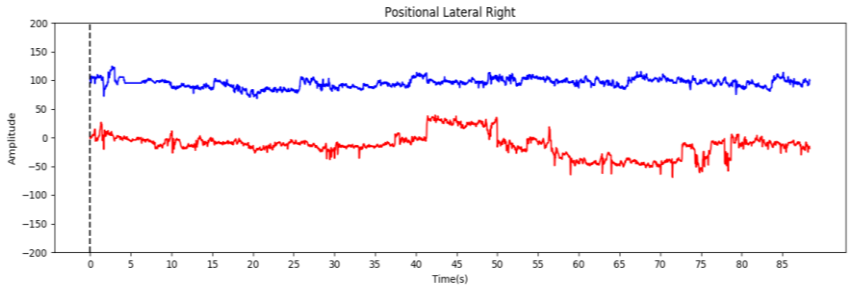


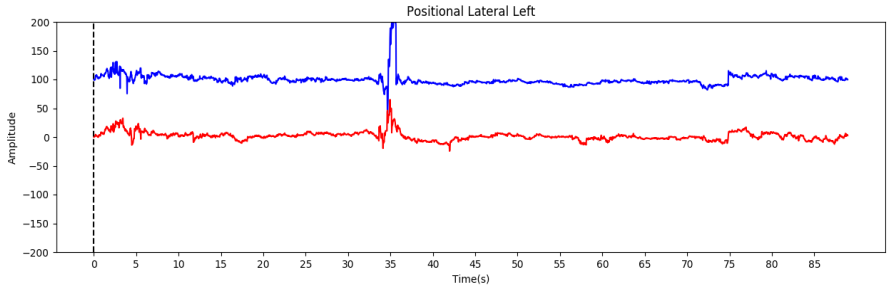






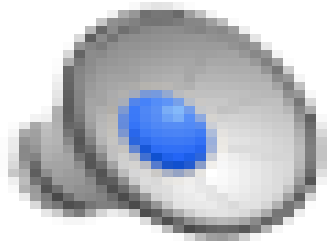
No torsion



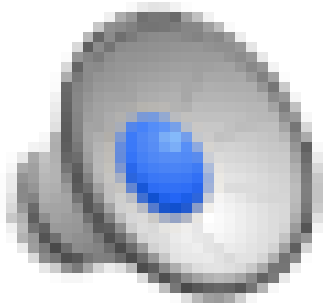


LATERAL APOGEOTROPIC - CUPULOLITHIASIS LEFT

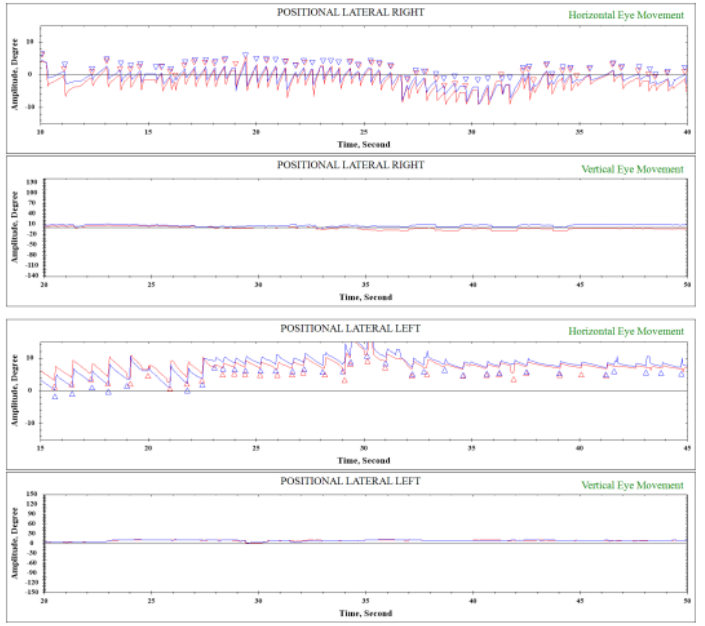
Lateral right



Lateral left



	Right Eye SPV(°/sec)	Right Eye Beats	Left Eye SPV(°/sec)	Left Eye Beats
Lateral Right Horizontal	13	80	11	81
Lateral Right Vertical	0	0	0	0
Lateral Left Horizontal	-6	51	-6	51
Lateral Left Vertical	0	0	0	0



LIGHT CUPULA

- Direction changing geotropic nystagmus on Supine head roll – stronger to affected side
- No latent period
- Non-fatigable
- Null point should be identifiable
- Does not respond to Barbeque or Gufoni maneuvres
- Usually self-limiting in a few weeks

(Kim, 2017)

THEORY BEHIND LIGHT CUPULA

- Normally Cupula and endolymph have the same specific gravity
- Cupula synthesizes sulfated proteoglycans
- Secreted in endolymph
- Altered homeostasis of these macromolecules
- Change of specific gravity of endolymph vs. cupula

(Bergenius & Tomanovic , 2006)

HEAVY ENDOLYMPH THEORY

Specific gravity of endolymph may increase due to

- Labyrinthine hemorrhage
- Inner ear hypoperfusion (eg. After stellate ganglion block)
- Inflammation
- Intracochlear schwannoma (increased protein)

CLASSIFICATION OF ANTERIOR CANAL BPPV (Califano)

1a: "certain" AC

Presence of a positional vertical down-beating paroxysmal nystagmus evoked through the straight head hanging positioning and sometimes through the Dix- Hallpike test.

In such positions, possible presence of a clockwise torsional component for the left AC or of a counterclockwise torsional component for the right AC.

Canal conversion in typical posterior canal BPPV (TPC) during or immediately after (no more than two days) the therapeutic manoeuvre, characterised by a vertical up-beating nystagmus, clockwise for the left canal and counter-clockwise for the right canal.

1b: "Probable" AC

As reported in 1a, but with a direct resolution of disease without canalar conversion in TPC.

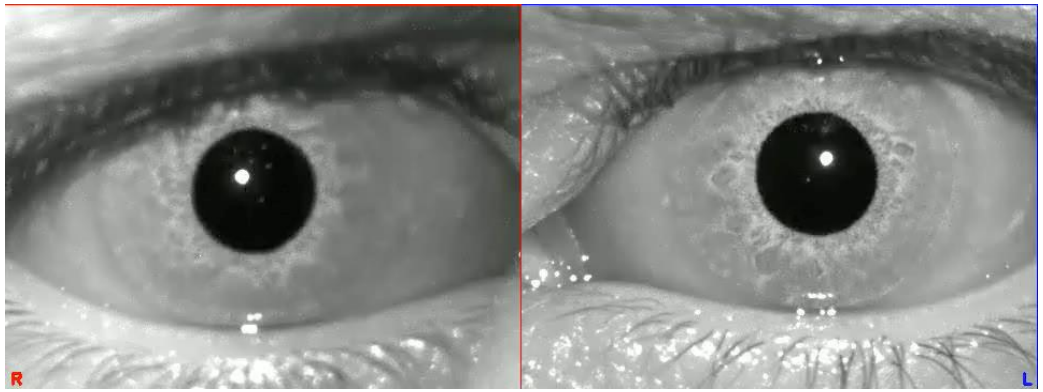
1c: "Possible" AC

Persistence of symptoms after five cycles of therapeutic manoeuvers.

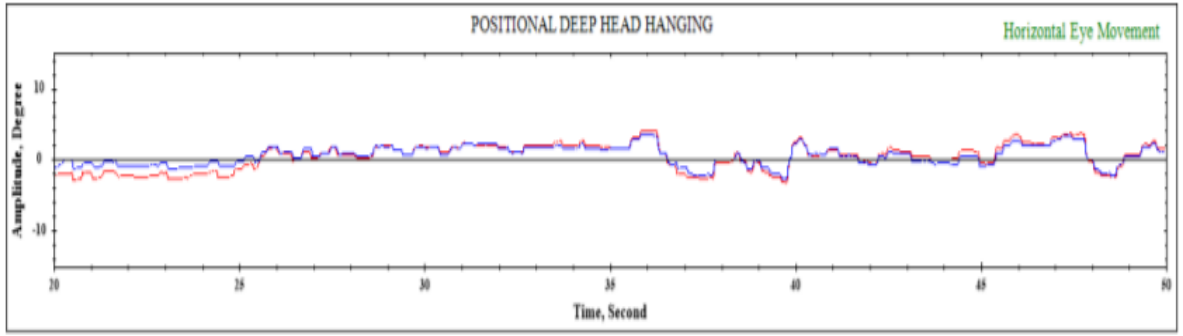
MRI does not show any neurological disease as a presumed cause of the nystagmus

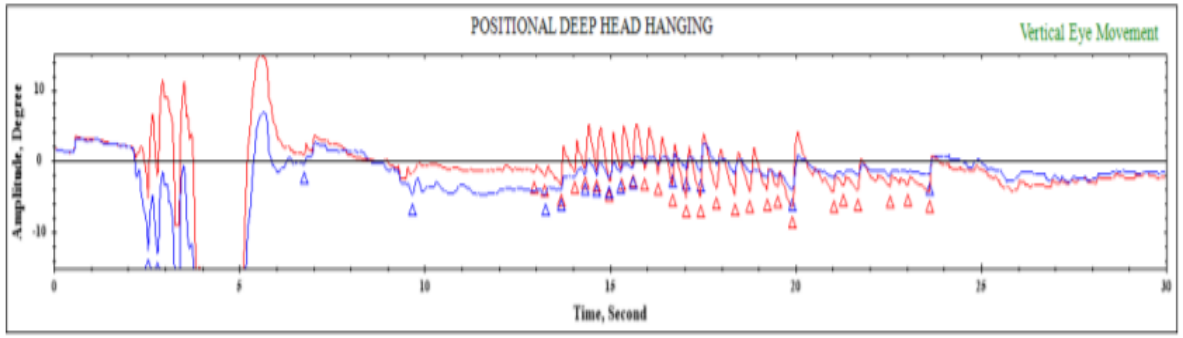
LEFT ANTERIOR CANAL BPPV

Deep Head Hanging

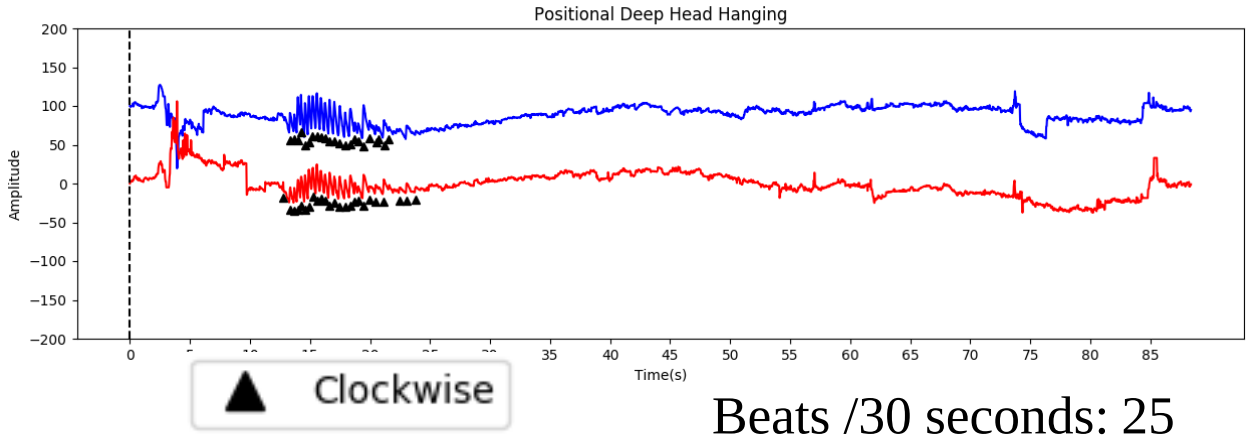


	Right Eye SPV(°/sec)	Right Eye Beats	Left Eye SPV(°/sec)	Left Eye Beats
Head Hanging Horizontal	0	0	0	0
Head Hanging Vertical	-23	26	-23	20



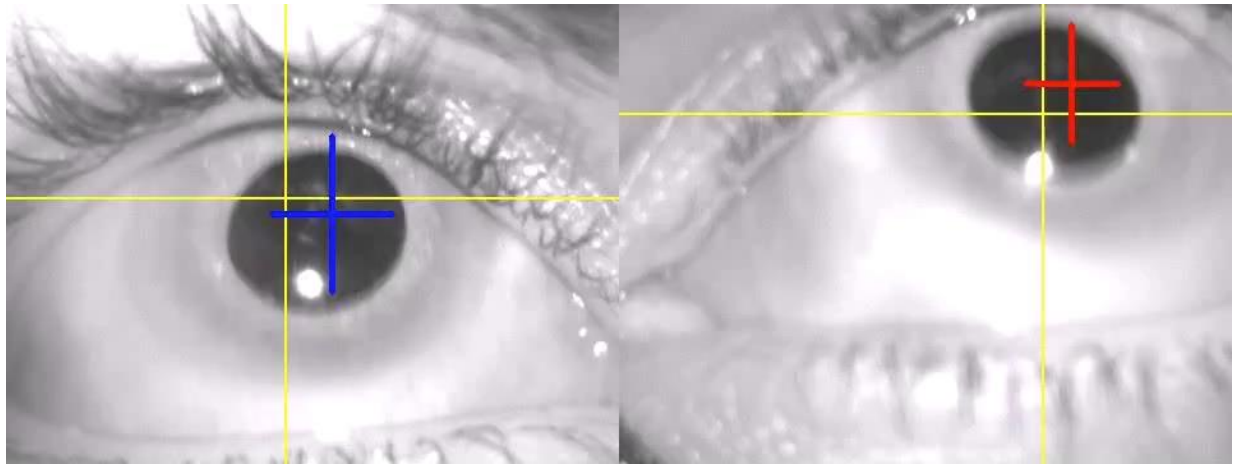


Torsion

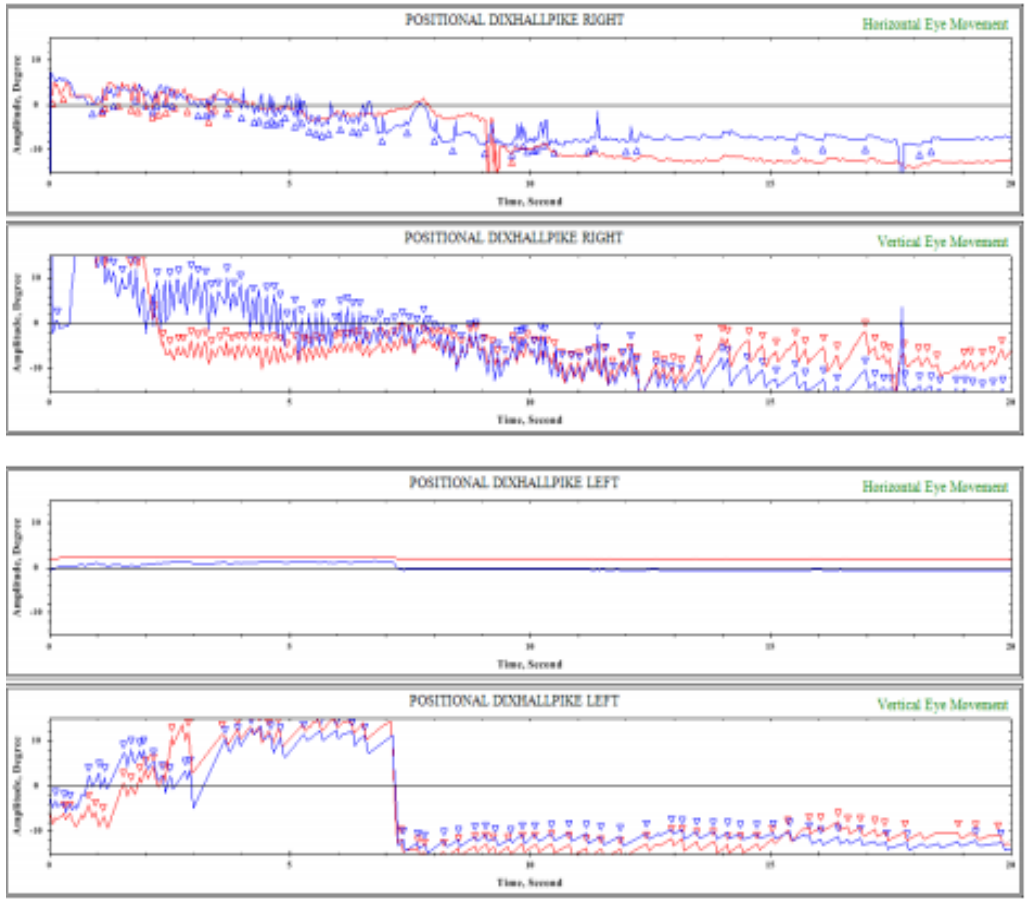


Beats /30 seconds: 25

POSITIONAL NYSTAGMUS : ATYPICAL / CENTRAL

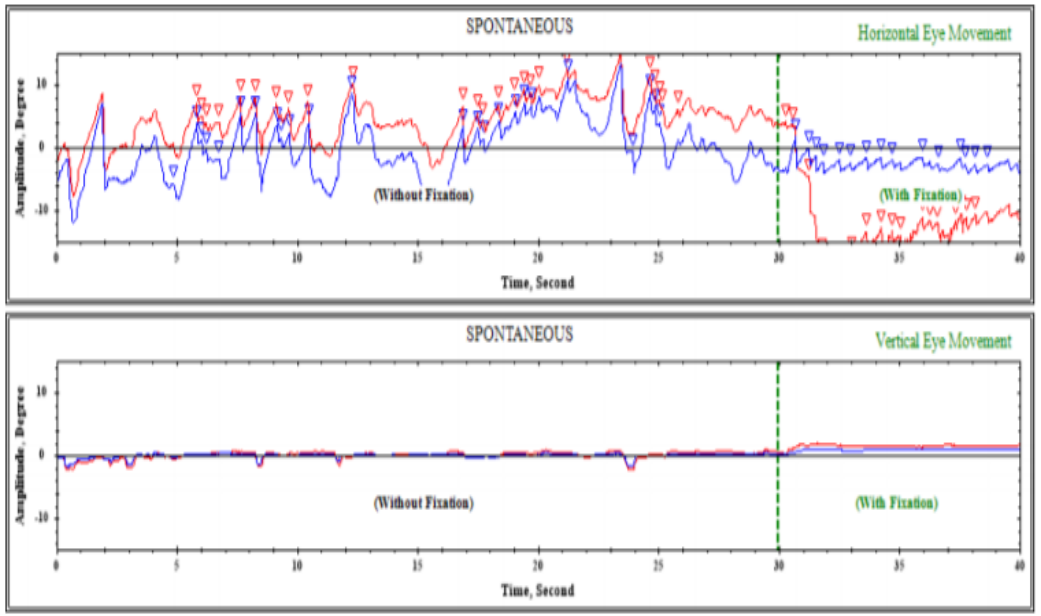


	Right Eye SPV(°/sec)	Right Eye Beats/20s	Left Eye SPV(°/sec)	Left Eye Beats/20s
Dix-Hallpike Right Horizontal	-33	16	-34	53
Dix-Hallpike Right Vertical	34	100	56	98
Dix-Hallpike Left Horizontal	0	0	0	0
Dix-Hallpike Left Vertical	18	62	15	60

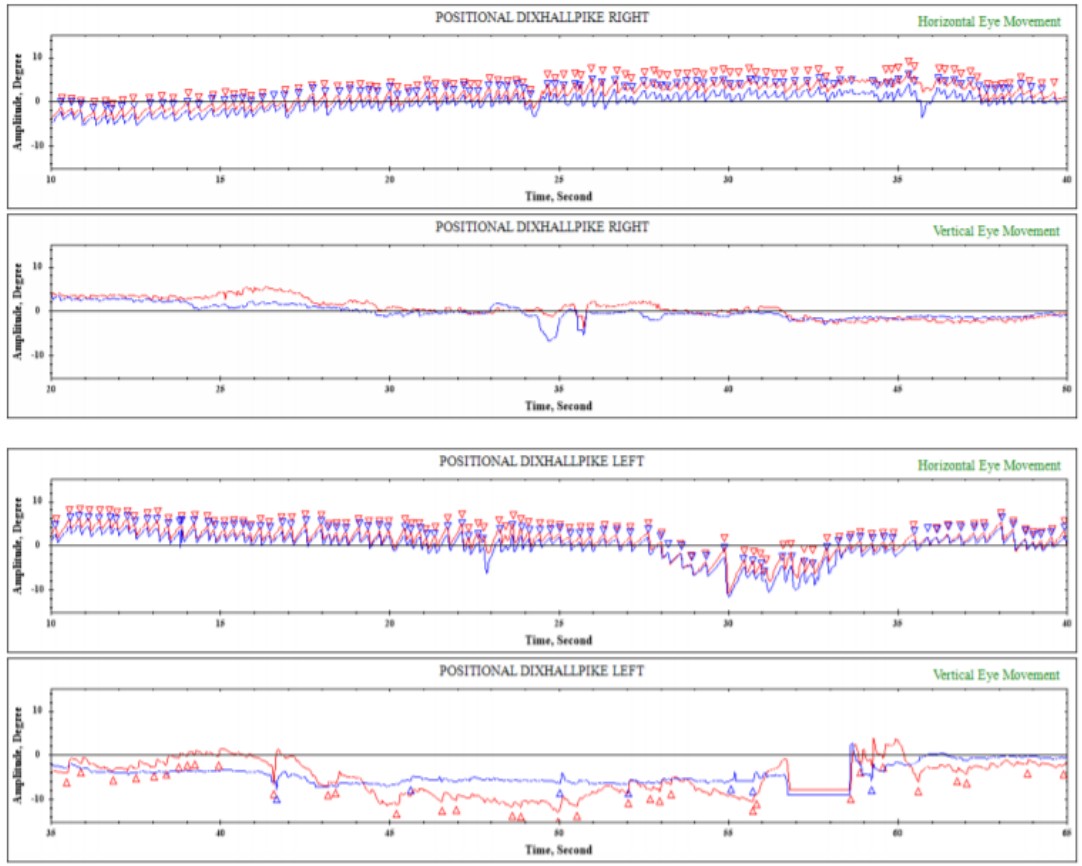


Spontaneous Nystagmus : Superimposed on all positional tests

Nystagmus Direction	Right Eye SPV (/sec)	Right Eye Beats/30 sec	Left Eye SPV (/sec)	Left Eye Beats/30 sec
Horizontal Left Beating	10	25	14	25
Horizontal Right Beating	0	0	0	0
Vertical Up Beating	0	0	0	0
Vertical Down Beating	0	0	0	0



	Right Eye SPV(°/sec)	Right Eye Beats	Left Eye SPV(°/sec)	Left Eye Beats
Dix-Hallpike Right Horizontal	11	186	11	191
Dix-Hallpike Right Vertical	0	0	0	0
Dix-Hallpike Left Horizontal	13	221	15	208
Dix-Hallpike Left Vertical	-13	65	-11	12



ABILITY TO DETECT ATYPICAL NYSTAGMUS

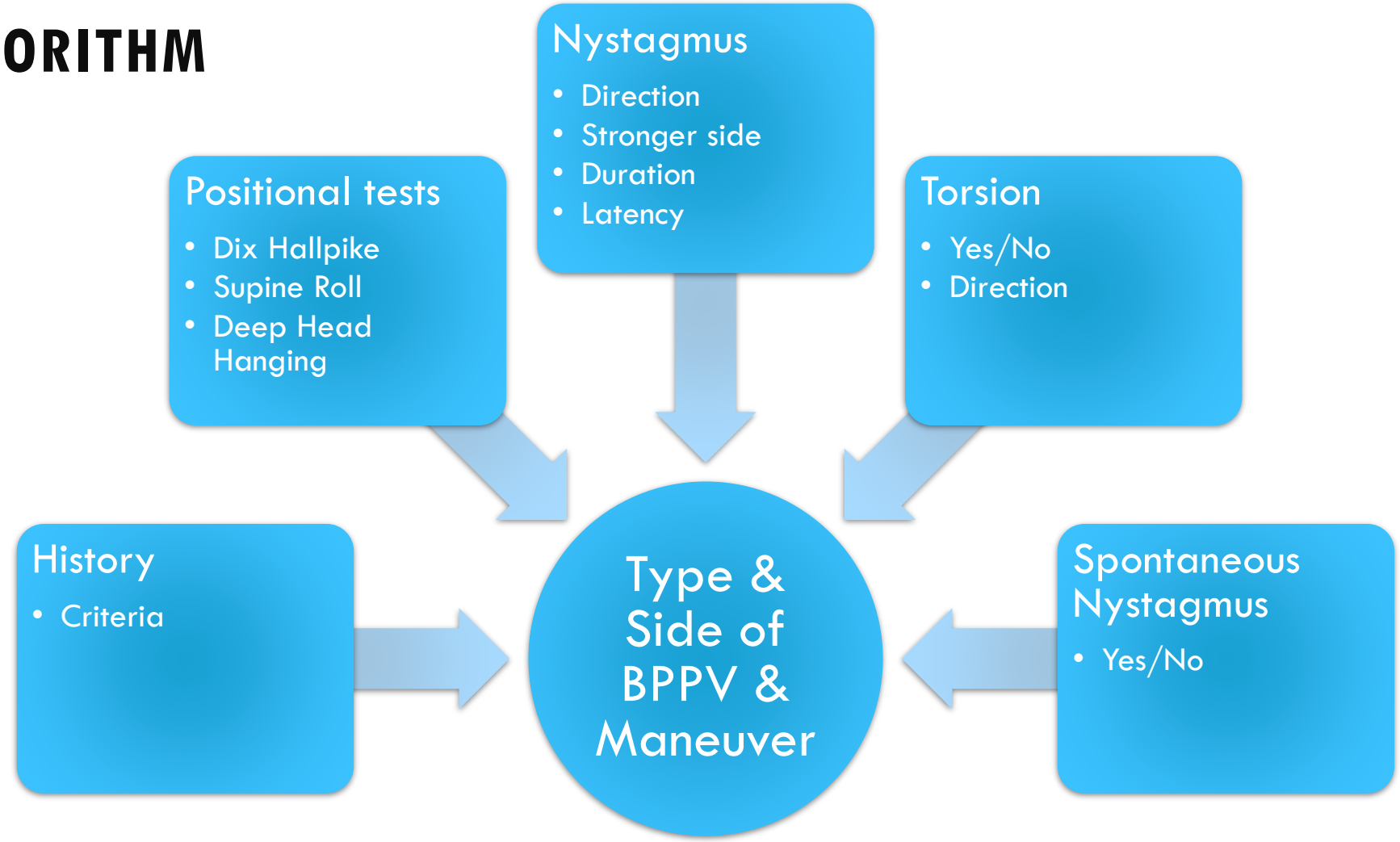
Horizontal in D-H

Torsional on Supine head roll

Direction changing

Non-fatiguable

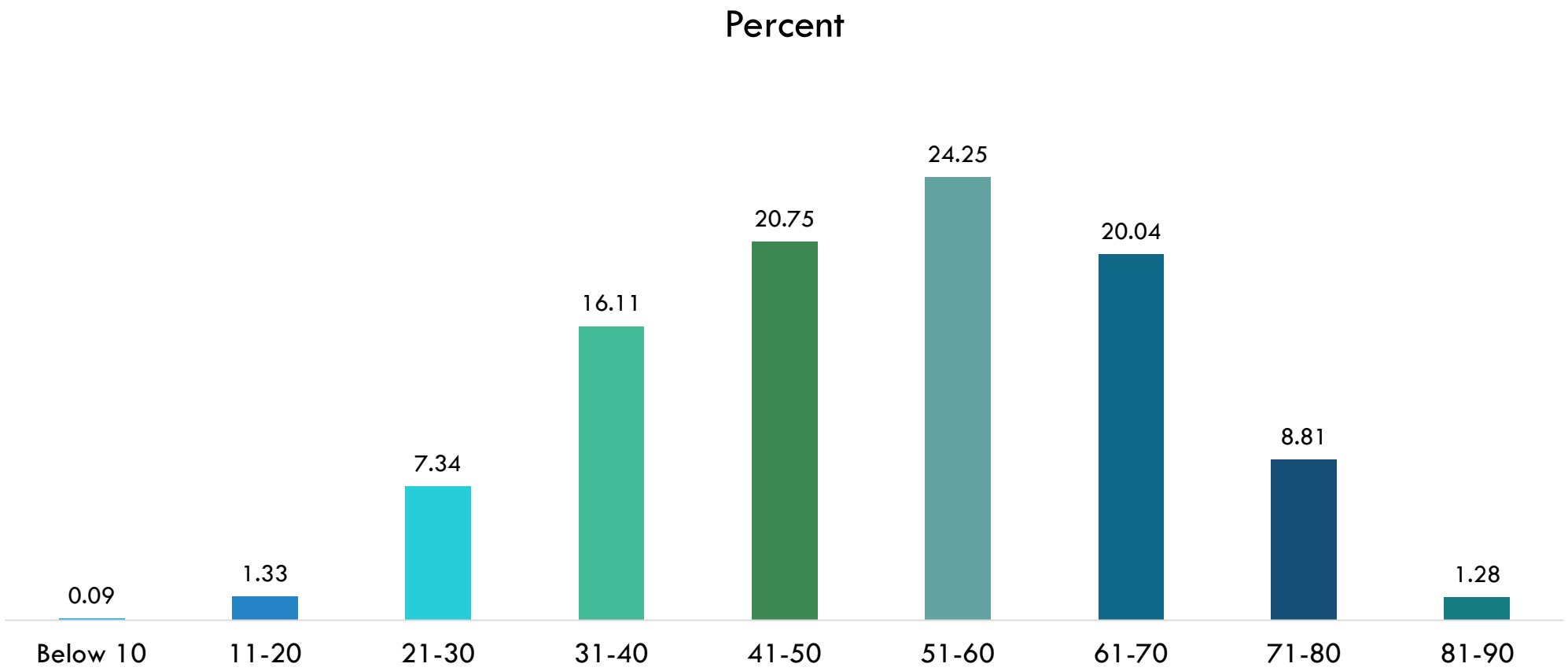
ALGORITHM


Nystagmus
• Direction
• Stronger side
• Duration
• Latency
Positional tests
• Dix Hallpike
• Supine Roll
• Deep Head Hanging
Torsion
• Yes/No
• Direction
History
• Criteria
Type & Side of BPPV & Maneuver
Spontaneous Nystagmus
• Yes/No

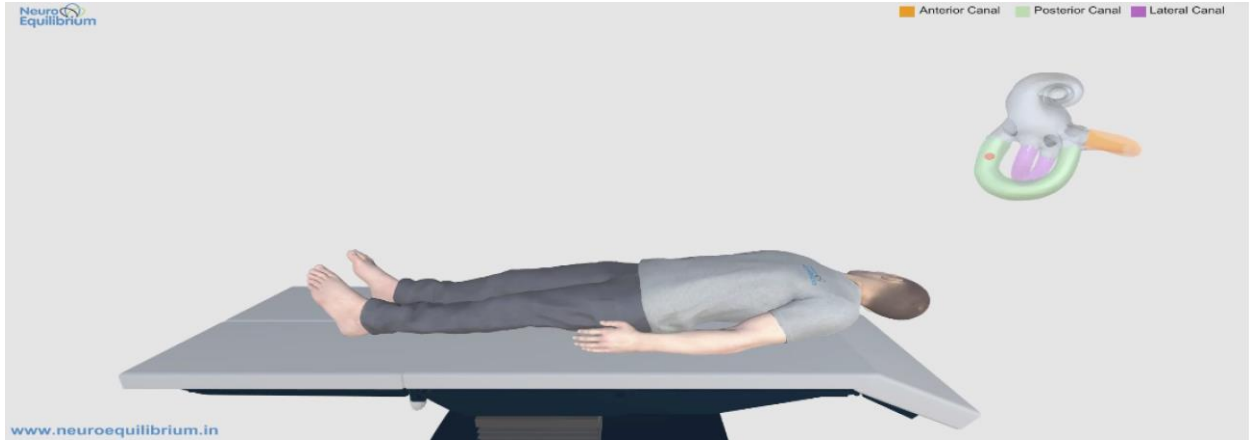
OUR EXPERIENCE : 1388 BPPV PATIENTS IN 1 YEAR

Type of BPPV	No. of pts.	%
PC- Long Arm Canalithiasis	795	57.3 %
PC- Short Arm Canalithiasis	8	0.6 %
PC Downbeating	139	10.0 %
PC Cupulolithiasis	8	0.6 %
HC Canalithiasis	187	13.5 %
HC Cupulolithiasis	110	7.9 %
AC	89	6.4 %
Multicanal	52	3.7 %

AGE WISE DISTRIBUTION



BPPV SIMULATOR



- 3D computer generated model of the labyrinth
- Enables placement of the debri
- Demonstrates how movement of the head influences orientation of each canal and how the debri will then move
- Any maneuver can be incorporated
- Principles of gravity and fluid dynamics govern debri movement
- The 3D model can also be imported from CT scan

HOW SIMULATION CAN HELP

- Illustrating sequence of events during repositioning
- Enabling to optimize angulation and positions for repositioning
- Understanding multi-canal BPPV treatment
- Explaining why maneuver may be ineffective
- What happens when a wrong maneuver is done
- Canal switch
- Development of future maneuvers


THE FUTURE IS HERE

THANK YOU

GENDER PREVALENCE

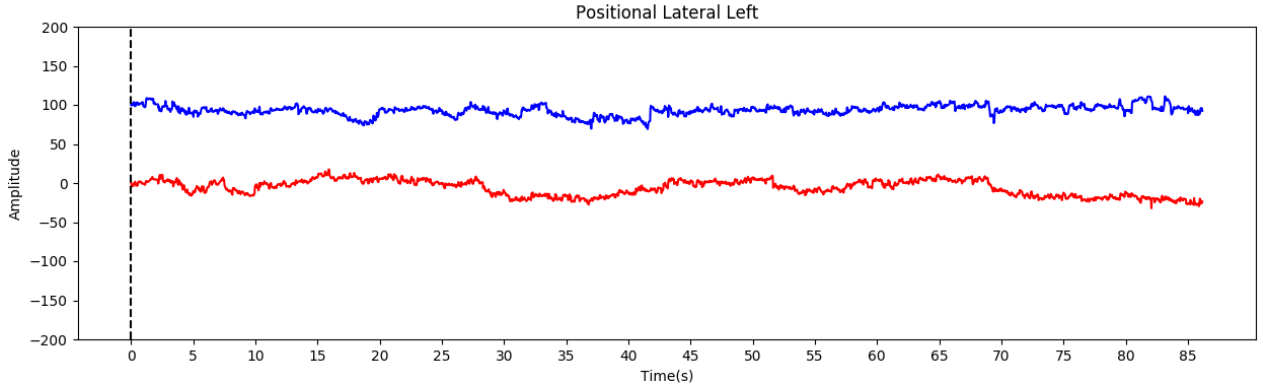
Total number of patients – 2111

Gender	Number of patients	Percent (%)
Males	950	45
Females	1161	55

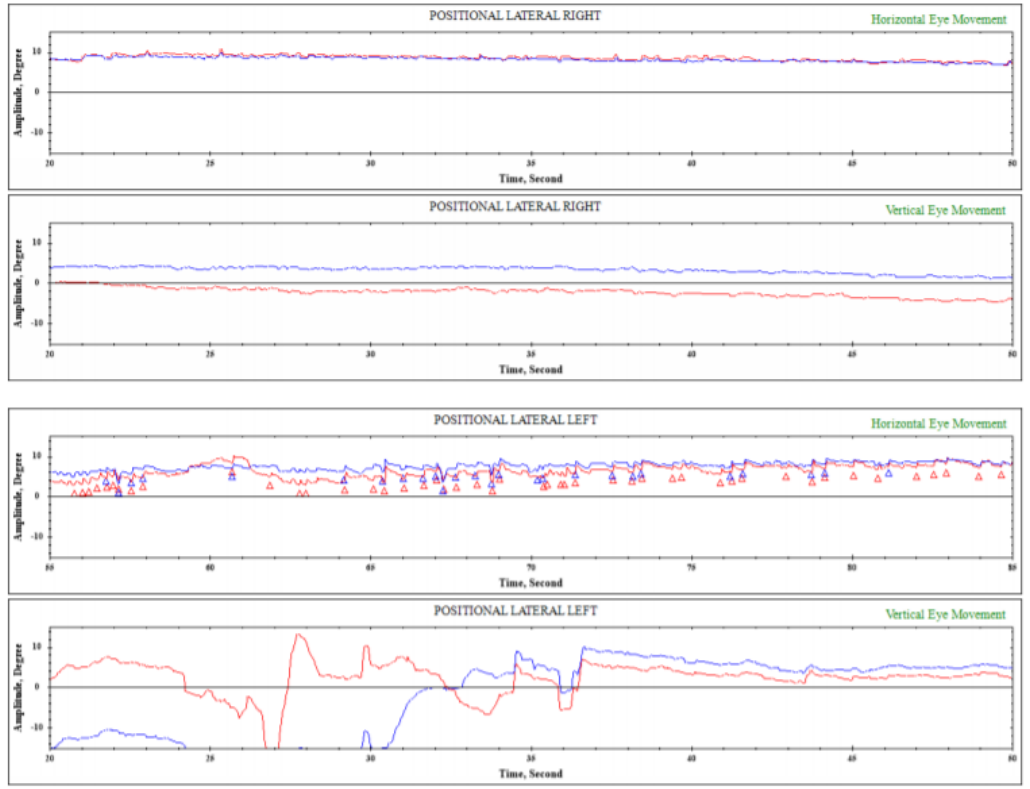
HORIZONTAL – APOGEOTROPIC NYSTAGMUS

Lateral Left

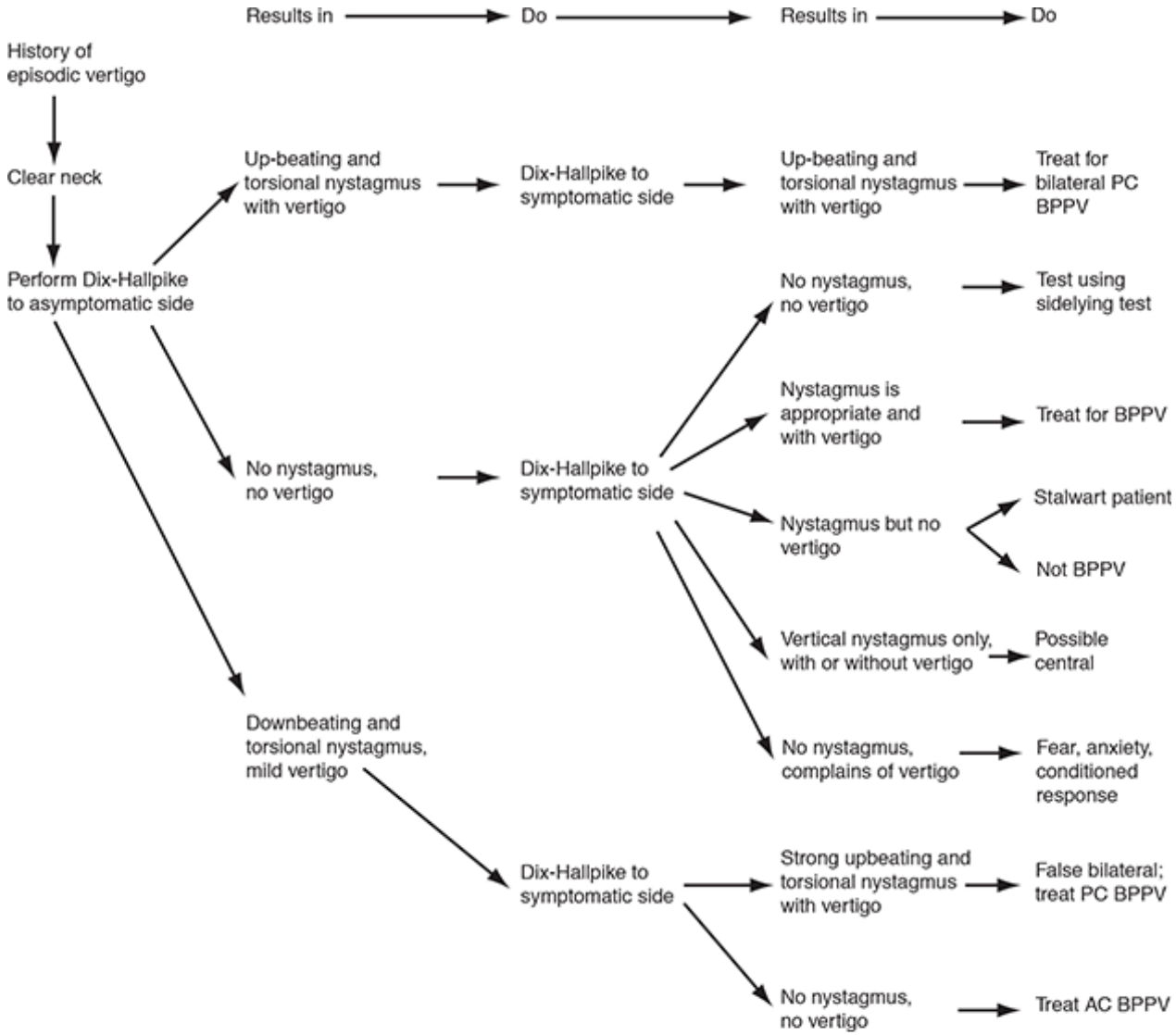
No torsion



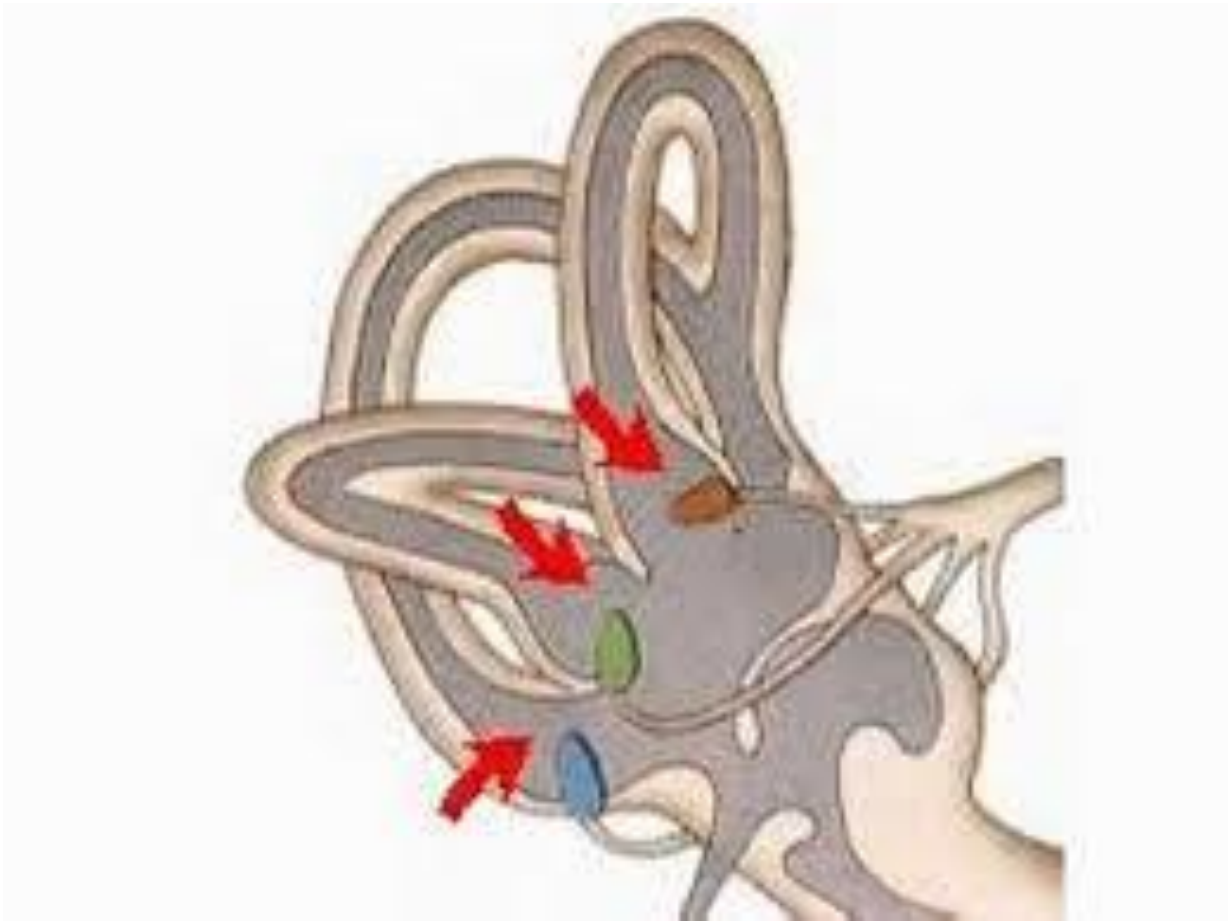
	Right Eye SPV(°/sec)	Right Eye Beats	Left Eye SPV(°/sec)	Left Eye Beats
Lateral Right Horizontal	0	0	0	0
Lateral Right Vertical	0	0	0	0
Lateral Left Horizontal	-15	90	-17	61
Lateral Left Vertical	0	0	0	0



The movement of the conglomerate causes an ampullofugal or ampullopetal deflection of the endolymph depending on the direction of sedimentation and thus leads to a stimulation or inhibition of the vestibular hair cells. This model of the pathomechanism of BPPV can predict the direction, latency, duration and fatigability of the typical nystagmus, as well as changes in these parameters after head manoeuvres.



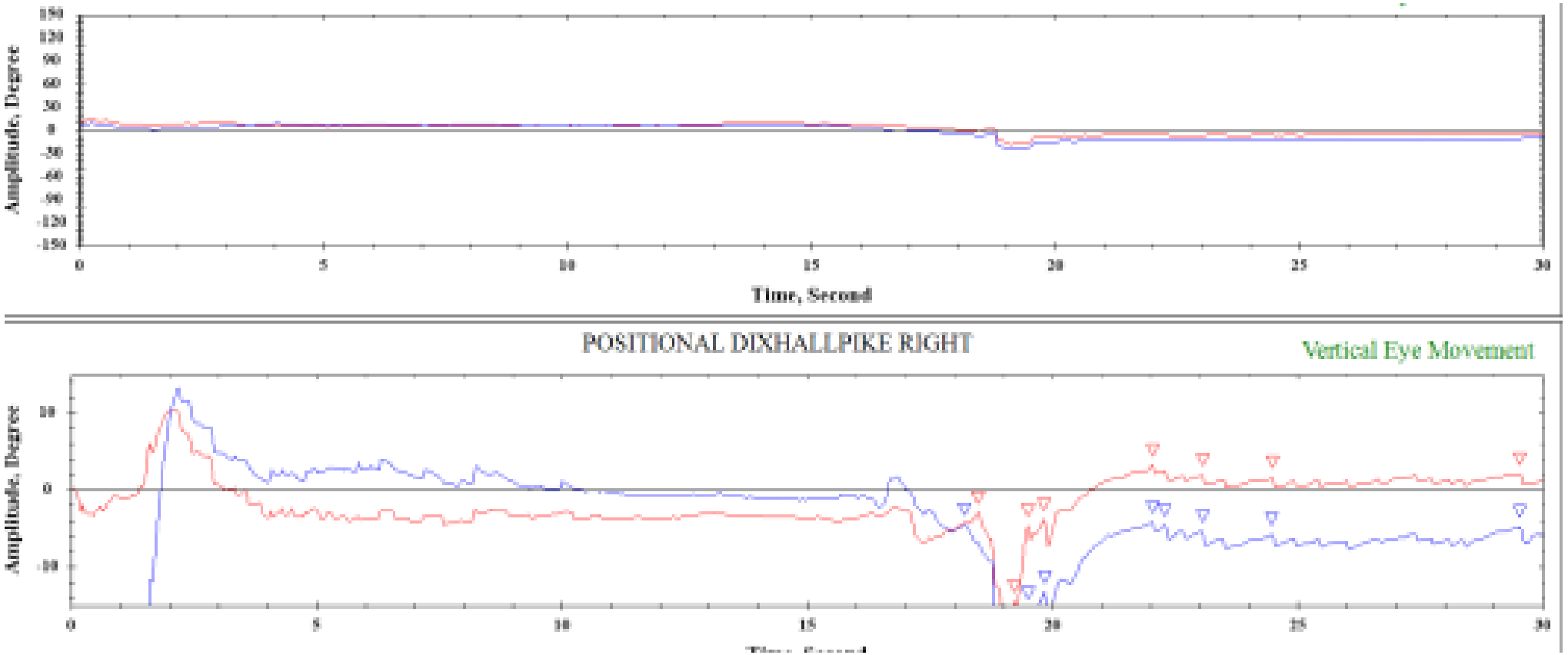
CUPULA PLACEMENT



POSTERIOR SEMICIRCULAR CANAL

Type	Diagnosis	Treatment
Short Arm Canalithiasis	Only vertigo in positional movements but no nystagmus on Dix Hallpike dubbed as BPPV type 2 or subjective BPPV	Brisk Epley
Long Arm Canalithiasis	Classical ipsitorsional upbeat nystagmus localized to the side of the Dix Hallpike with latent period and fatigue after 1 minute and reversal of direction on sitting	Epley
Cupulolithiasis	Like long arm but with shortened latency and prolonged duration of more than a minute and severe intense vertigo	Semont
PSCC Downbeat	Possibly from common crux without any torsional component; with contralateral torsion could be a cupulolithiasis	Yacovino

SHORT ARM


Amplitude, Degree
Time, Second
POSITIONAL DIXHALLPIKE RIGHT
Vertical Eye Movement
Amplitude, Degree