

# Isolated and Combined Semicircular Canal Dysfunction in Patients with Vestibular Schwannoma

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## ABSTRACT

Video-Head Impulse Testing (vHIT) is used to obtain vestibular functionality of all 6 semicircular canals (SCC) in patients with vestibular schwannomas (VS). Data of vHIT and conventional caloric irrigation is compared. Results show that vHIT has its surplus value in assessing patients with VS: it is complementary to caloric testing, since vHIT also provides additional and useful information about the functionality of all vertical SCCs, especially regarding *posterior semicircular canal dysfunction*, that would be missed, when only caloric data is obtained.

## BACKGROUND

According to standard protocols used at the Radboud University Medical Centre Nijmegen, all patients diagnosed with a vestibular schwannoma (VS) receive full assessment of balance functionality in order to pre- and/or postop evaluate the vestibular system. Recently, high-frequency video-Head Impulse Test (vHIT) was added to standard electronystagmographical (ENG) testing (i.e. vestibulo-oculomotor, rotary chair tests, caloric irrigation). In contrast and in addition to standard ENG, vHIT recordings has the advantage to assess the vestibulo-ocular reflex (VOR) of all vertical semicircular canal (SCC) function, i.e. posterior and anterior SCCs. Until now, clinically only horizontal SCC function is routinely investigated in patients with vestibular schwannoma using standard ENG, thus lacking any information about vertical SCC functionality.

## AIMS

- To investigate impact of vestibular schwannomas on vertical semicircular canal functionality
- To investigate the surplus value of vHIT responses (VOR) in patients with vestibular schwannomas, whilst showing ostensible normal ENG outcomes

## METHODS & MATERIALS

Adult patients with unilateral vestibular schwannoma (n=96) were included in the present study (49 female, 47 male; mean age 59;1 ± 12;9). Vestibular schwannoma was confirmed by MRI (58% right side; 42% left).

**Standard multichannel ENG recordings:** Smooth Pursuit, Spontaneous Nystagmus, Gaze testing, OKN, Random Saccade; Rotary chair (Velocity-Step); Caloric water irrigation (cold/warm), all according to standard clinical procedures.

**vHIT<sup>1</sup>:** a pilot study comparing vHIT systems with/without use of goggles (see Fig 1), revealed that the more patient-friendly goggle-less system was able to record overt as well as covert saccades using a high sampling rate of 100 Hz (see Table 1)<sup>2</sup>. Correction saccades were administered for at least 6 stimuli per SCC (horizontal, posterior, anterior). VOR gain was calculated and defined: abnormal horSCC < 0.8 and verSCC < 0.7.

Two different Video Head Impulse Test (vHIT) systems are used (Figure 1). Based on the results of a previous pilot study<sup>2</sup> (Table 1), the goggleless Ulmer vHIT was chosen to test patients. vHIT results are compared to the conventional electronystagmographic data.

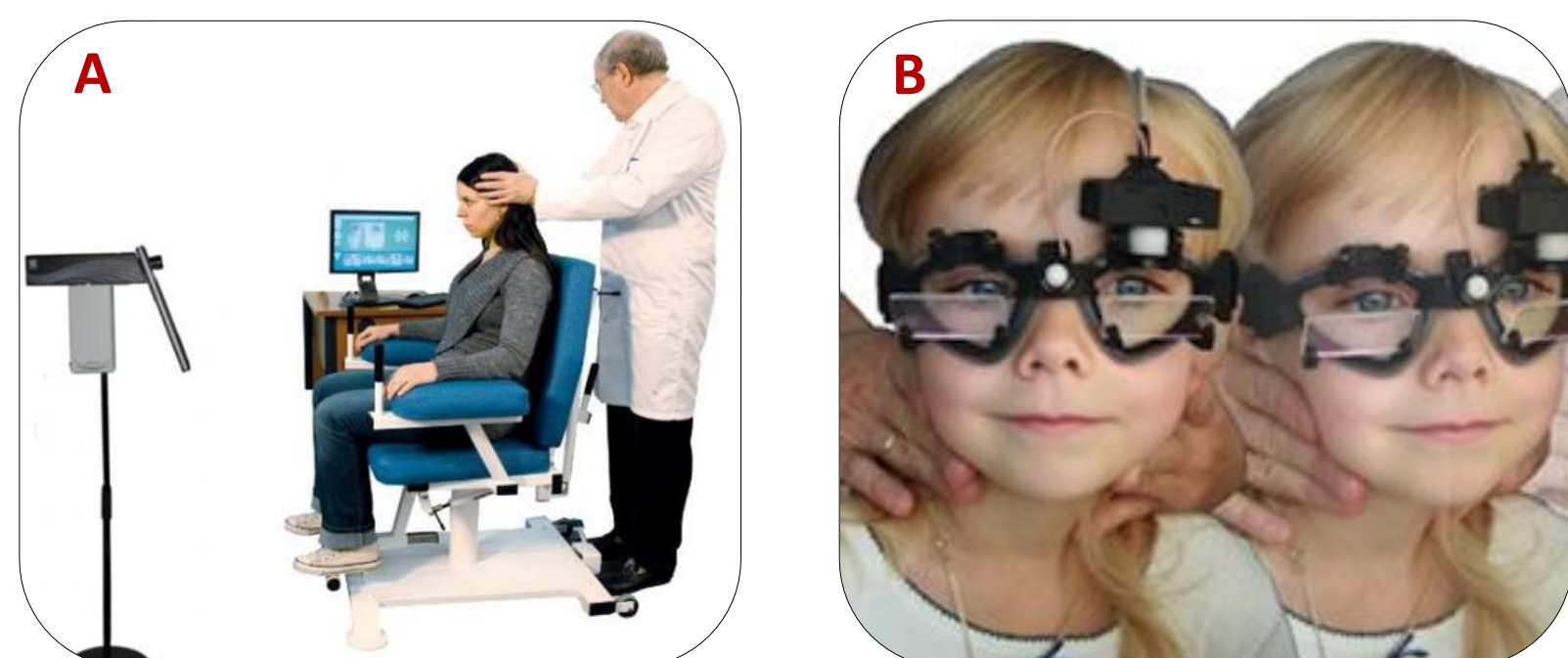


Figure 1. A) Set-up Synapsys Ulmer<sup>3</sup> vHIT system (left: without goggles) B) Autronic EyeSeeCam<sup>4</sup> device (right: with goggles)

Table 1. Three most important advantages of using a system without goggles

Feature	Synapsys	Autronic
Consistency results	✓	✗
Clinical applicability	✓	✗
Patients' comfort	✓	✗

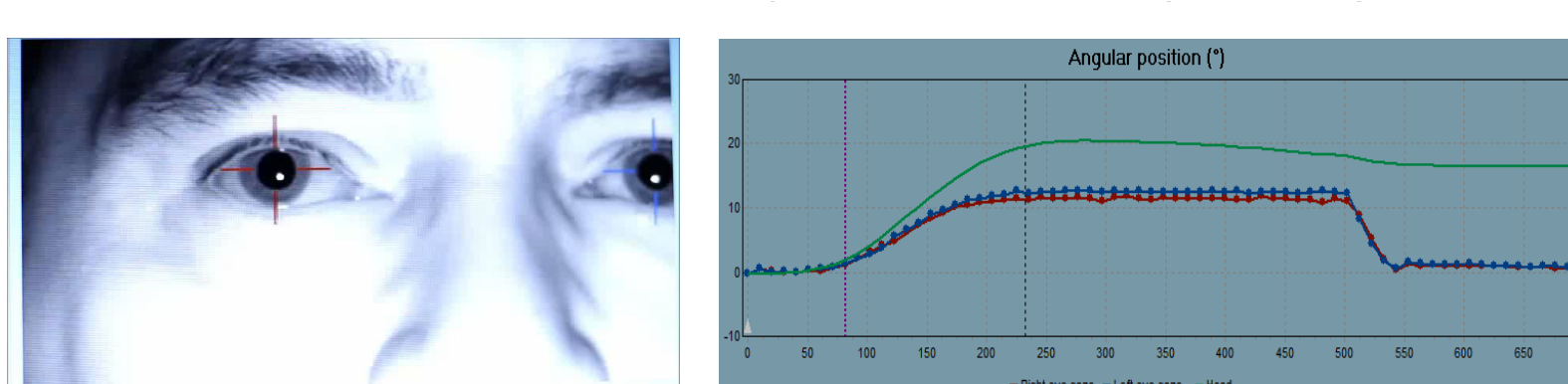


Figure 2. Typical example of an overt saccade (see left movie) in a patient with a unilateral vestibular schwannoma AD with a pathological VOR gain of 0.31 (pathological correction saccade of both eyes after about 500 ms; see right: graph)

## RESULTS

**vHIT results:** horizontal SCC responses were successfully obtained in all patients (n=96); however, in 13 patients, it was impossible to obtain reproducible vertical SCC responses, mainly because of excessive eye-blinking or drooping eyelids. Complete SCC data was available for 72 patients (see Table 2). 28/72 patients show a significant loss of VOR in the side of lesion of which 10 patients only in the posterior SCC.

**Caloric results:** horizontal SCC responses could be reliably obtained in 88 patients; rotary chair (not shown) and warm caloric irrigation was possible in all patients; in 5 patients, cold irrigation was not obtained. 43/88 show abnormal caloric responses at the side of lesion (of which 41 confirmed by a pathological asymmetry, i.e. IAD >20%).

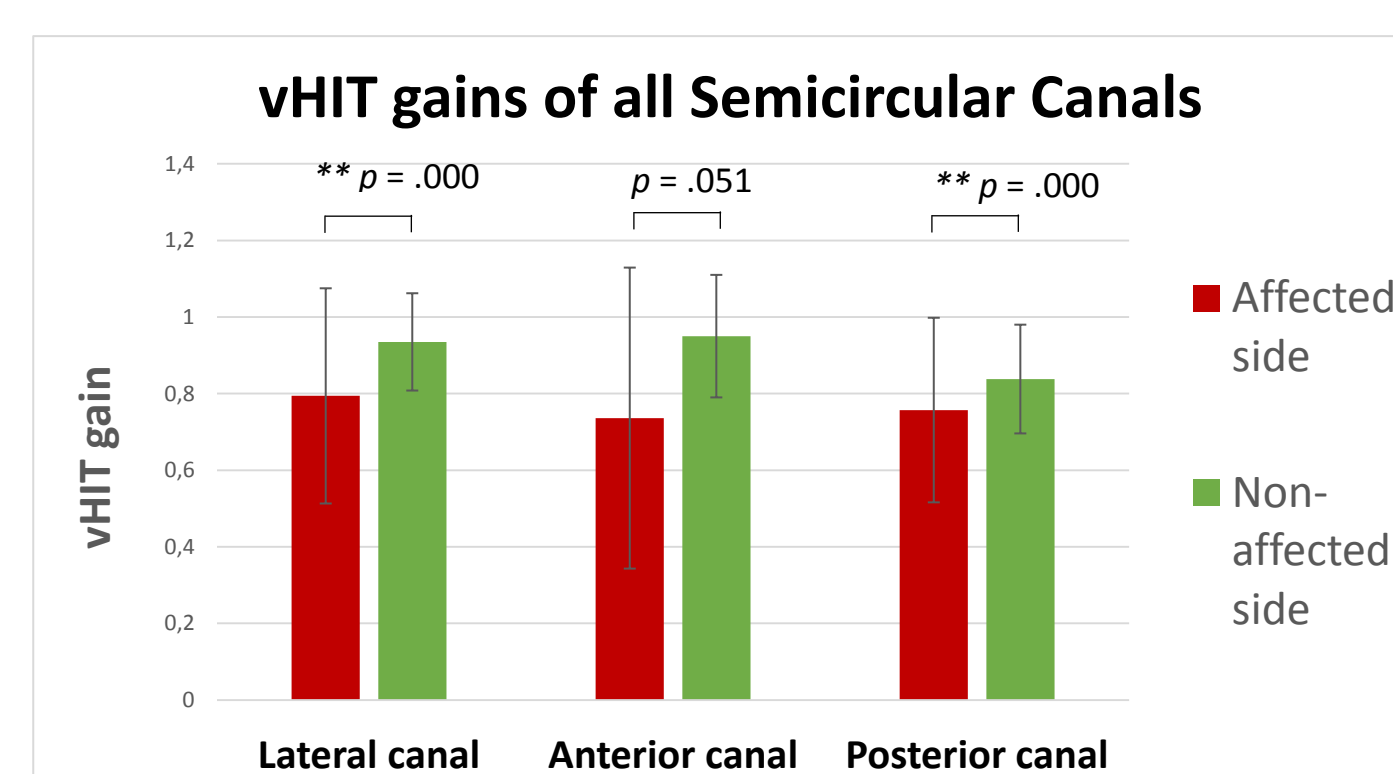


Figure 3. Mean vHIT gains of all SCCs for affected and non-affected side: in contrast to the anterior canals (NB. large spread affected side), gain difference between the affected and the non-affected side is significantly different for lateral and posterior canals

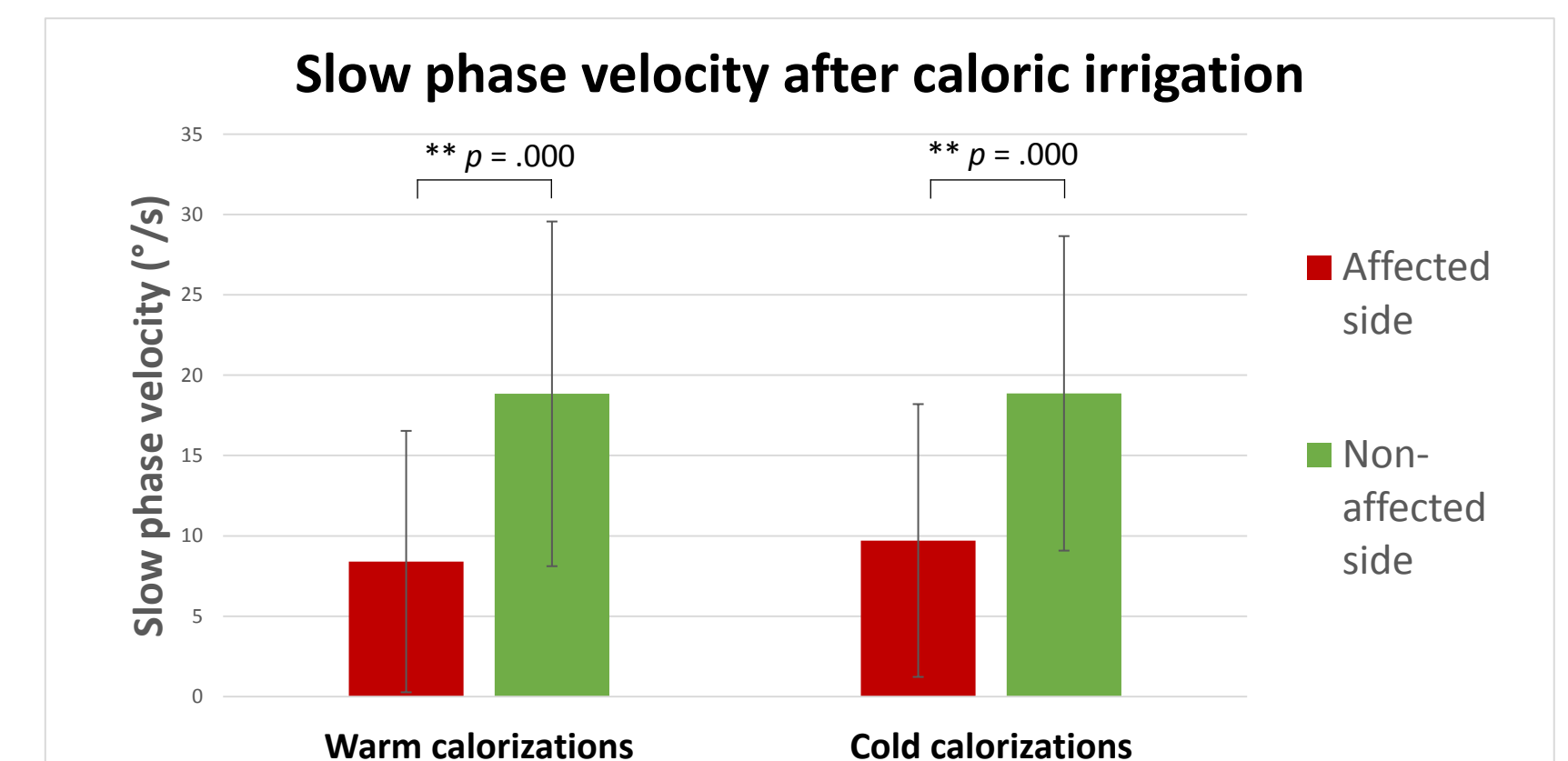


Figure 4. Mean nystagmus slow phase velocities (°/s) obtained with warm and cold water caloric testing for affected and non-affected side: SPVs of the affected side are significantly reduced

**Caloric and vHIT results:** 40/72 patients show normal caloric responses (regardless of asymmetry), while vHIT shows that 44/72 patients show no deviant VOR. 30% of the patients with an isolated loss in the posterior canal (see Figure 5) reveal normal and 70% hypofunctional caloric responses.

41% (7/17) of the patients with caloric hypofunction show normal VOR, while another 41% (7/17) show a loss of VOR in only the posterior canal. 93% (14/15) of all patients with a caloric areflexia show a pathological VOR with vHIT, of which 6 patients in only lateral and 5 in all SCCs.

In 7.5% (3/40) patients, vHIT results show an isolated posterior canal dysfunction, while caloric testing did not reveal any deviant values.

	Normal (asymmetry)	Hypo (asymmetry)	Arefl (asymmetry)	total
0	36 (21)	7 (6)	1 (1)	44
L	1 (0)	0 (0)	6 (6)	7
A	0 (0)	0 (0)	0 (0)	0
P	3 (2)	7 (7)	0 (0)	10
L+A	0 (0)	1 (1)	1 (1)	2
L+P	0 (0)	1 (1)	2 (2)	3
A+P	0 (0)	0 (0)	0 (0)	0
L+A+P	0 (0)	1 (1)	5 (5)	6
total	40 (23)	17 (16)	15 (15)	72

Table 2. Frequency table of vHIT versus caloric responses of 72 patients (numbers between brackets when significant side asymmetries were found). Isolated posterior canal dysfunction was found in 10 patients

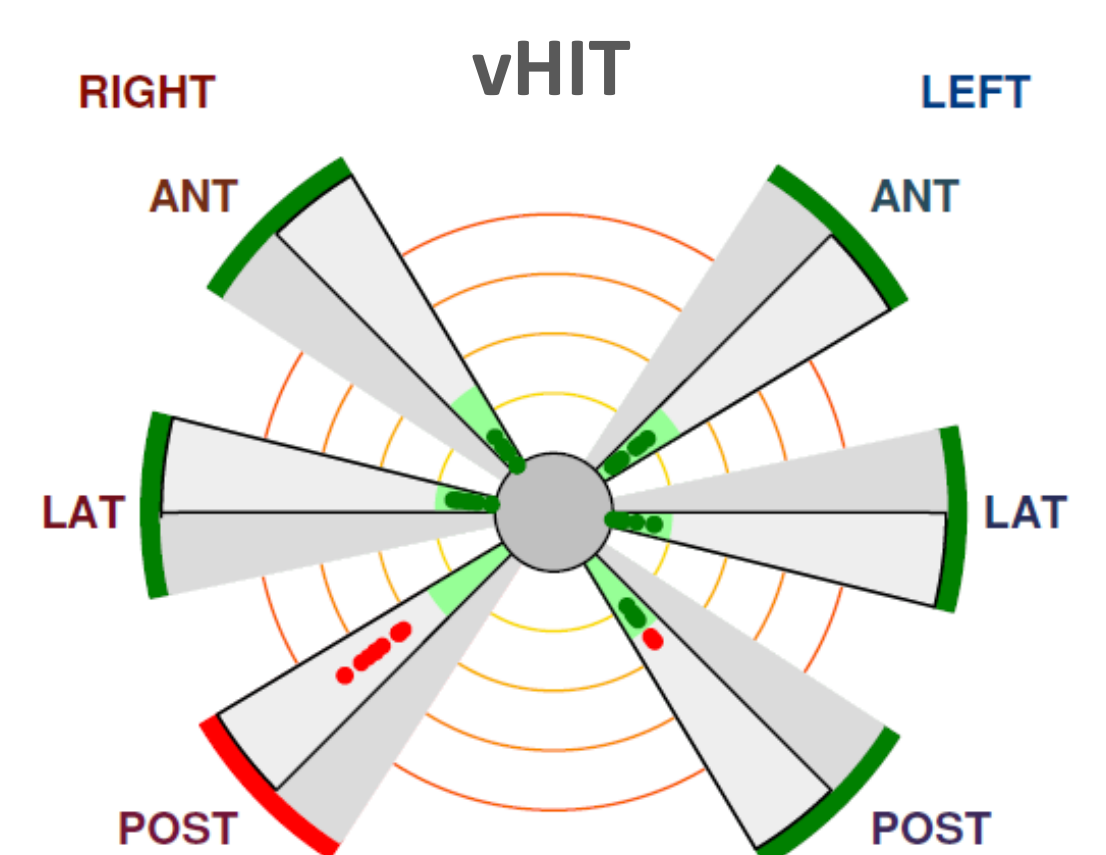


Figure 5. Typical example of a patient with normal calorics and an isolated right posterior SCC loss of the VOR obtained with video-Head Impulse Testing

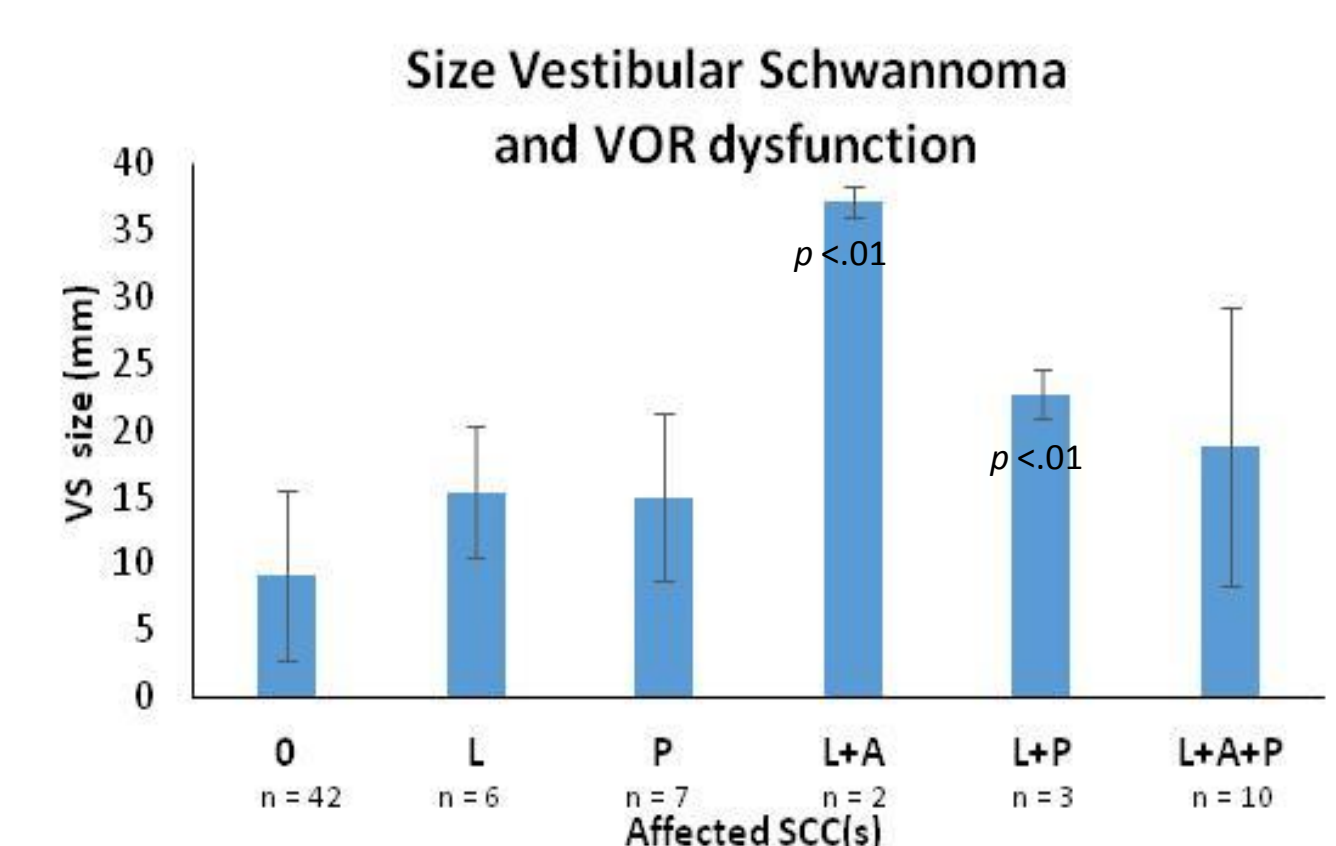


Figure 6. Combined and isolated SCC loss of VOR related to tumor size: (L+A) and (L+P) dysfunction significantly correlate with larger tumor size

## CONCLUSIONS

50% of all patients with vestibular schwannoma (VS) show abnormal results when results of caloric and vHIT are combined. However, patients with an isolated loss of posterior canal function show normal (30%) or hypofunctional (70%) caloric results. Thus, only caloric irrigational testing seems inadequate to assess patients with VS. Present data show that vHIT recordings - in addition to calorics - significantly contributes to SCC assessment in the affected vestibular organ, especially regarding the posterior SCC, that occurs as an isolated loss in 14% of the cases.

## References:

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- Beynon AJ, Voncken A & Mylanus EAM (2014) The growing need of vestibular assessment in cochlear implant candidates and users. *J. Vestibular Research, Equilibrium & Orientation, special issue on XXVIII Bárány Society Meeting*, May 25-28, Buenos Aires, Argentina, (24):15.
- www.synapsys.fr <sup>4</sup>) www.eyeseecam.com