NHS Assessment of the vertical semi-circular canals using Manchester University **NHS Foundation Trust** vHIT: preservation of anterior canal function in patients with severe to profound hearing loss in criteria for cochlear implant.

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- Vestibular assessment or screening on 90 patients with severe to profound hearing loss listed for cochlear implant
- 38% of patients had normal vestibular function in all six canals
- 11% had absent high frequency vestibular-ocular reflexes in all canals (Bilateral Vestibular hypofunction)
- 43% had partial vestibular weakness, often involving the lateral and posterior canals but sparing the anterior canals



PARTICIPANTS

- 90 patients with bilateral severe to profound hearing loss awaiting surgery for cochlear implant
- Patients had a diverse range of aetiologies, most common was idiopathic progressive hearing loss.
- Mean age: 60 years (SD: 19.7)
- 32 met departmental criteria for full vestibular assessment, which included Video Head Impulse Testing (VHIT)
- 58 had did not meet criteria and had vHIT alone
- Of the 90 patients, 61 had all six semicircular canals assessed by vHIT

METHODS

• Full vestibular assessments include a targeted and patient-specific battery which might include vHIT, VNG,

mCTSIB, positioning, SVINT, Calorics and cVEMPS.

- vHIT performed using Natus ICS Impulse and OtosuiteV v4.1
- Vertical canal vHIT used method with head at 45°, target visualized out of eccentric gaze and head movements towards and away from the target (in LARP or RALP) planes)

vHIT RESULTS

A normal vHIT result shows gain within the normal range, a normal curve morphology, NORMAL and no saccades of a significant size A vHIT result suggesting absent VOR

typically gain will be <0.1

ABSENT VOR

Mean Gains: 0.8 shows no curve (or very shallow curve), 200 large covert and/or overt saccades and 100

A vHIT result suggesting weakness in that canal shows a shallow curve, covert and/or overt saccades, and a gain value below the normal range (0.8 laterals, 0.7 verticals),

WEAKNESS

ARTEFACTS

The ICS Impulse is the only vHIT device which is validated against scleral search coils for the vertical canals (MacDougall et al., 2013). However, vertical canals are particularly prone to artefact, and eliminating and identifying these is vital to accurate testing. In some cases it is very difficult to tell artefactual trace from a truly pathological result.

Results for 33 patients (66 ears) with partial vestibular weakness, stratified by canal

These patients had weakness in one or more canals, with some functioning remaining in one or more canals





'Phase shift' caused by stimulation out of canal plane – causes lowered gain

Typical eyelid artefact in left posterior canal – causes low gain and small 'double peak' or flat top



Typical eyelid artefact in right posterior canal – can resemble covert saccades. Saccade reanalysis tab can be used to disqualify

Typical biphasic eyelid artefact in left anterior canal –large 'double peak' and can lower gain



DILEMMA. This trace may well represent eyelid artefact, though could represent low gain with a cluster of covert saccades. Video playback can be used to review whether the pupil tracking is affected by the eyelid, though slower frame rates may not always catch very quick blinks.



PATIENT A. Female, 41. Childhood meningitis + progression. No imbalance or dizziness. Clustered, covert saccades suggest that weakness are longstanding and likely well compensated.



PATIENT B. Male, 55. Idiopathic progressive hearing loss. Chronic imbalance, worse in the dark. Note the eyelid artefact in left posterior with genuine covert and overt saccades.



CONCLUSIONS

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In Cochlear implant candidates where vestibular function was not normal or completely absent, partial vestibular

Right lateral Left Anterior Right Anterior Left Posterior Right Posterior Left lateral

These results reflect not only anterior canal sparing but also the higher incidence of artefacts in the posterior canals, the difficulties of interpretation for the right posterior canal, and unusually, the higher incidence of weakness in the left compared with the right lateral canal. There was no correlation between hearing loss aetiology and specific canal weaknesses.

- weaknesses tended to occur in the lateral and posterior semicircular canals.
- With one exception, anterior canal function was only abnormal in cases of bilateral vestibular hypofunction
- These results reflect previous work that describes' anterior canal sparing' in certain pathologies such as Meniere's disease, aminoglycoside vestibulotoxicity and idiopathic cases (Tarnutzer et al., 2016; Van Stiphout et al. 2022).
- No clear patterns were seen in this cohort with respect to aetiology of hearing loss. -
- Speculatively, sparing of anterior canal function may explain why vertical gaze stability exercises are often less _ provoking than horizontal
- There were also several cases of isolated posterior canal weakness, which has previously been linked to age- related bilateral vestibular deterioration or 'Presbyastasis' (Lerchundi et al. 2020)
- Further work may examine whether vertical canal function has any bearing on post-operative dizziness



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PATIENT C. Female, 59. Idiopathic progressive hearing loss. No imbalance or dizziness. Bilateral posterior canal weaknesses

