Summary
Bilateral vestibulopathy is a heterogeneous disorder of the peripheral and/or (rarely) central vestibular system, leading typically to disabling symptoms like dizziness, imbalance, and/or oscillopsia (1–3). It affects up to 95 million adults in Europe and the USA (4). However, in many cases vestibular hypofunction is missed or misdiagnosed. One of the reasons is that the vestibular testing still faces many diagnostic challenges (5–10), which lead to inter- and intra-laboratory differences regarding diagnosing vestibular function loss (11). Therefore, it is imperative to standardize vestibular testing (Chapter I).

The current vestibular test battery mainly involves tests of the Vestibular-Ocular Reflex (VOR). One of the most frequently used tests of the high-frequency VOR, is the video Head Impulse Test (vHIT) (6). Different type of head movements (inwards versus outwards, active versus passive) can be performed during vHIT testing, which all differ regarding predictability. To evaluate the influence of the predictability of head movements on the VOR gain and saccadic response, sixty-two healthy subjects were tested using SHIMP (suppression head impulse paradigm) in four conditions: active and passive head movements, for both inward and outward head impulses. VOR gain, latency of the first saccade, and the level of saccade grouping (PR-score) were compared among conditions. Inward and active head movements were considered to be more predictable than outward and passive head movements. It was found that a higher predictability in head movements lowered gain only in passive impulses, and shortened latencies of compensatory saccades overall. For active impulses, gain calculation was affected by short-latency compensatory saccades, hindering reliable comparison with gains of passive impulses. Predictability did not substantially influence grouping of compensatory saccades (Chapter II).

A bilateral horizontal VOR gain of < 0.6, measured by vHIT, is one of the diagnostic criteria for bilateral vestibulopathy according to the Báràny Society (1). Sixty-four patients with bilateral vestibulopathy were tested using three commercially available vHIT systems, which utilized different techniques of tracking head and eye movements and methods of gain calculation. The systems showed clinically significant differences in the VOR gain, which might hinder proper diagnosis of patients with bilateral vestibulopathy. This result demonstrated an urgent need for standardization of vHIT testing (Chapter III).

Dynamic visual acuity (DVA) can be measured using different testing procedures. Testing DVA while walking on a treadmill, is considered to be a “close to reality” tests. Forty-four patients with bilateral vestibulopathy and 63 healthy subjects performed the DVA test on a treadmill at 0 (static condition), 2, 4 and 6 km/h (dynamic conditions). A significant loss of DVA was demonstrated in the group of bilateral vestibulopathy patients. However, since bilateral vestibulopathy and age significantly increased the dropout rate at faster walking speeds, it was recommended to use age-matched controls and individual “preferred” walking speeds in older subjects, when testing DVA on a treadmill (Chapter IV).

There is no clinically available therapeutic option to restore the vestibular function. Fortunately, the vestibular implant (VI) could become a clinically useful device in the near future (12), which is able to (partially) restore vestibular function by electrical stimulation, similar to the cochlear implant restoring the function of the cochlea.

Different eye movement analysis algorithms are used in vestibular implant research to quantify the electrically evoked vestibulo-ocular reflex (eVOR). It was investigated whether these analysis techniques need to be adapted to optimise quantification of the electrically evoked VOR (eVOR). For this, “Natural” VOR responses were obtained in six age-matched healthy subjects and eVOR responses were obtained in
eight bilateral vestibulopathy patients fitted with a vestibular implant. VOR outcomes were calculated using three different eye movement analysis paradigms: raw eye trace analysis, half-cycle fitting of traces, full-cycle fitting of traces. It was demonstrated that the type of eye movement analysis algorithm significantly influenced VOR outcomes, especially regarding the VOR gain and asymmetry of the eVOR in bilateral vestibulopathy patients fitted with a vestibular implant. VOR axis and phase shift did not differ significantly between eye movement analysis algorithms. In healthy subjects no clinically significant effect of eye movement analysis algorithms on VOR outcomes was observed. For the analysis of the eVOR, the excitatory and inhibitory phases of stimulation should be analyzed separately due to the inherent asymmetry of the electrically evoked VOR. A half-cycle fitting method can be used a more accurate alternative to analyzing full-cycle traces (Chapter V).

Finally, the high-frequency DVA was tested using the functional head impulse test (fHIT), in a 72-years old patient with bilateral vestibulopathy and fitted with a vestibular implant (MED-EL, Innsbruck, Austria). It was found that the vestibular implant was able to significantly improve the high-frequency DVA. This functional benefit of the VI illustrated again the feasibility of the VI for clinical use in the near future (Chapter VI).
References


