REVIEW

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Management of vestibular schwannoma: focus on vertigo

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Practice Points

- Vestibular schwannoma (VS) patients often experience vertigo with significant impact on their quality of life.
- The incidence of vertigo in VS patients is not known and there is a relative paucity of tools for assessment of vertigo.
- It is unclear if patients with symptomatic vertigo as the sole symptom of VS benefit from radiosurgery.
- Development and validation of a vertigo scale would allow clinicians to access severity and frequency of symptoms in a consistent manner.

SUMMARY This article reviews published literature on vertigo and a 'sense of imbalance' affecting patients who are treated with radiosurgery (RS) for vestibular schwannoma. This is a relatively understudied complaint, along with tinnitus, in this patient population, despite its significant impact on quality of life. It is also a symptom that is most inconsistently impacted by either RS or surgery. This article aims to highlight the importance of this symptom in patients managed for vestibular schwannoma primarily with RS to encourage a more systematic study of vertigo as an outcome measure and to help elucidate its potential etiology.

Dizziness is a common patient complaint, with up to 30% of patients complaining of this symptom [1]. Patients with dizziness constitute a large and heterogeneous group that seeks evaluation by various medical professionals: primary care doctors, neurologists, otolaryngologists, radiation oncologists and neurosurgeons. Determining the cause of dizziness is difficult because of the large number of possible etiologies (neurological, cardiac and psychological), and the fact that patients often have difficulty describing their symptoms. Therefore, dizziness presents a complex and often frustrating diagnostic challenge [2]. Further complicating diagnosis is

the inconsistent use of nomenclature to describe dizziness symptoms.

The general complaint of 'dizziness' is divided into four subtypes with different underlying etiology: vertigo, disequilibrium, presyncope and psychological dizziness. Vertigo is a false sensation of movement of oneself or the environment that typically occurs in paroxysmal attacks [3]. By contrast, disequilibrium is a sense of postural imbalance associated with a loss of balance [1]. Presyncope is a feeling of faintness, while psychological dizziness is typically related to anxiety or mood disorders [4]. In both presyncope and psychological dizziness, there is no

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illusion of movement, distinguishing them from vertigo. Vertigo is the most common cause of dizziness and accounts for approximately 54% of dizziness cases seen in primary care clinics [5].

Vertigo originates from vestibular disease of the peripheral nervous system or CNS and is often a unilateral, asymmetric impairment of the vestibular system that causes an illusory sensation of movement. Vertigo is classified as peripheral or central based on the etiology. The peripheral vestibular system includes the semi-circular canals, utricle, saccule and vestibular nerve. The vestibular nuclei, brainstem, spinal cord, vestibular cortex and vestibulo-cerebellum constitute the central vestibular system. The patient's history, neurological examination and imaging studies help differentiate peripheral and central causes of vertigo. One commonly used diagnostic test for vertigo is caloric testing or electronystagmography, which records involuntary movements of the eye (nystagmus) related to vestibular dysfunction. While vestibular system dysfunction can be quantified in this manner, the severity of vertigo symptoms can only be ascertained from the patient's report.

Peripheral vertigo is significantly more common than central vertigo, affecting approximately 75% of patients with this complaint [6]. Benign paroxysmal positional vertigo, vestibular neuritis and Menière's disease account for 90% of peripheral vertigo cases [6]. Both central and peripheral vertigo cause nystagmus. The nystagmus characteristic of peripheral vertigo is horizontal, unidirectional and associated with conjugated gaze [1,7]. By contrast, central vertigo causes nystagmus that is torsional, multidirectional and often changes direction with changes in gaze [7]. The presence of other neurological signs is characteristic of central vertigo [6–8]. Common associated signs include dysarthria, paresthesia, ataxia, changes in sensory and motor function, and less commonly, a gait disturbance may be observed [6–8]. Vestibular migraine, cerebrovascular disease and cerebello-pontine angle tumors all cause central vertigo [9]. This review focuses on central vertigo in vestibular schwannoma (VS) patients.

VS, or acoustic neuroma, is a benign tumor arising from the Schwann cell sheath surrounding the vestibular branch of cranial nerve VIII. Schwannomas comprise 5–10% of all intracranial tumors and are typically unilateral [10]. They generally grow slowly into the internal

auditory canal and cerebropontine angle, displacing adjacent cerebellum, pons, and V and VII cranial nerves in more advanced stages of growth. Progression of symptoms over months to years is typical of the disease. Most commonly, VS patients present with unilateral hearing loss from involvement of the cochlear component of cranial nerve VIII. Decision to treat is multifactorial and dependent on such characteristics as tumor size, patient age, overall symptomatology (including hearing loss, facial numbness, imbalance, headaches and tinnitus), and the patient's overall medical fitness and expectations. However, a small subset of patients experience vestibular symptoms or a sense of 'imbalance', often in conjunction with diminished hearing. It is not clear how management of VS impacts vestibular signs and symptoms, or a subjective sense of 'dizziness'.

Review of published literature suggests that approximately 40–50% of patients with VS have some form of vestibular dysfunction [11,12]. However, some reports suggest that vestibular dysfunction may affect as many as 60–75% of VS patients [13]. The true incidence of vertigo in this patient population is not known, in part because of a lack of clinical focus on vestibular difficulties and the absence of a suitable questionnaire or screen to characterize these symptoms. Furthermore, published studies often focus on general vestibular symptoms rather than vertigo specifically. In the few studies specifically examining vertigo, it was found to be the presenting symptom in 10–15% of VS patients [12,14]. Given that as many as 10% of VS patients have normal to minimally impaired hearing at the time of diagnosis, presumably there are patients with vertigo and minimal hearing loss who are not referred for treatment [13].

Currently, there are no studies investigating vertigo in VS patients as a primary research end point. There are three commonly accepted treatment modalities for VS: radiosurgery (RS); microsurgery; and conservative management with serial clinical follow-up. Most studies comparing different treatment approaches focus on comparing neurologic morbidity, hearing preservation outcomes and facial nerve function in particular [15–19]. It is well established that RS and microsurgery both have excellent tumor control rates approaching 95% [20,21]. Most studies recommend RS as the preferred treatment because of reduced post-treatment hearing

loss and facial nerve dysfunction [16,18,20,22]. For example, in a recent study of 70 patients treated with RS and followed for 2 years, Arthurs and colleagues reported tumor control with a mean dose of 12.7 Gy in nearly all treated patients and 65% hearing and 95% facial nerve preservation [20]. Given the already excellent tumor control rates with any intervention, VS treatment has shifted beyond local tumor control to preserving quality of life (QOL) and maintaining neurologic function. However, because there are no long-term, large-scale studies analyzing vertigo in VS patients, it is difficult to determine whether patients with severe vertigo would benefit from γ -knife RS.

Quality of life

Vertigo from VS can be quite debilitating with pronounced negative impact on patients' QOL [19,23–29]. Some vertigo attacks can last for hours and can happen frequently through the day. This can limit patients' independence (e.g., ability to walk without assistance, drive or work). In fact, Myrseth *et al.* found that vertigo has a more pronounced negative impact on QOL than any other VS symptom, including hearing loss [27]. Given the potential magnitude of disability, one can argue that even VS patients managed conservatively should undergo treatment if they experience severe vertigo at any point in their disease course [19].

In their literature review of the impact of VS treatment on QOL, Whitmore *et al.* found that patients treated with RS had an overall better QOL experience than those treated with microsurgery or managed conservatively with serial imaging [21]. As a corollary, there are studies demonstrating a decrease in QOL after VS surgery [16,30,31]. Whitmore *et al.* discovered a number of limitations in the current literature. Studies of vertigo in VS patients vary widely in the length of follow-up and have limited long-term QOL data. Moreover, investigators have used an array of generalized QOL questionnaire instruments, making it difficult to compare results [21]. Evaluation of QOL in VS patients could certainly be influenced by the choice of questionnaire. These instruments – including the Short Form 36 survey, Glasgow Benefit Inventory and Health Status Questionnaire – are general health status assessments. Therefore, it is unclear which reporting questionnaire most reliably measures the impact of vertigo on QOL.

Vertigo scales

Several reporting tools exist to assess vertigo. The Dizziness Handicap Inventory (DHI) and Vertigo Symptom Scale (VSS) are the most commonly used. These were originally applied to peripheral vertigo patients and are structured questionnaires where patients report symptoms (VSS) and their impact on QOL (DHI). The DHI scores have been used as proxy measures of vertigo severity in the literature [17,32,33]. In the last several years, investigators have started to use the DHI in patients with central vertigo [15,34]. However, it has never been validated for use in this setting, and in particular in VS patients. Moreover, the DHI is designed for QOL assessment and not as a measure of vertigo symptom severity.

■ Dizziness Handicap Inventory

Developed in 1990 by Jacobson and Newman, the DHI addresses the perceived impact of dizziness in daily life and quantifies the degree of disability [35]. It consists of 25 questions divided over three sections: physical factors that cause/worsen dizziness; emotional impact of dizziness; and functional limitations imposed by dizziness. Scores range from 0 to 100 with each question being categorized as 'yes' (4 points), 'sometimes' (2 points) and 'no' (0 points). A higher score indicates more severe dizziness and greater impairment (disability). The DHI has been validated for reliability and consistency [29,36].

The DHI has been utilized in two prospective studies evaluating QOL of VS patients treated with RS or microsurgery [18,22]. Pollock *et al.* followed a cohort of VS patients with tumors <3 cm treated with either microsurgery (36 patients) or RS (46 patients) at 3 months, 1 year and last follow-up (average of 42 months; range of 12–62 months) [22]. The primary end points were preservation of hearing and retention of facial nerve function. At each follow-up, the investigators found no significant difference in primary end points or tumor control between the two groups. During the last follow-up, however, they discovered that DHI scores (a secondary end point) were significantly worse in the microsurgery group (average DHI score: 16.5) than in the RS group (8.4). Interestingly, vertigo symptoms worsened, on average, 3 years after VS treatment (37 patients were followed for 36 months), suggesting that understanding vertigo in VS patients requires a multiyear

follow-up period. Similarly, Myrseth *et al.* prospectively administered a modified DHI called the Visual Analog Scale to VS patients receiving either RS or surgery [18]. As in the Pollock study, they found the level of disability to be worse in the microsurgery group. Moreover, the RS cohort reported better QOL than surgery patients via the Glasgow Benefit Inventory after 2 years of follow-up.

Other research suggests that patients' age and tumor size may be important factors in perceived disability from vertigo [17,19]. Wackym and colleagues administered the DHI and conducted caloric testing in VS patients before surgery or RS [17]. Prior to treatment, 22 out of 54 patients (41%) had caloric testing consistent with vestibular dysfunction. Patients in this study did not complete the DHI before treatment and were instead asked to recall pretreatment symptoms. At 6-month intervals after treatment (with an average follow-up of 48 months), researchers repeated MRI, caloric testing and the DHI. They observed that the largest changes were in vestibular function in the first 6 months after treatment. Additionally, statistically significant differences in DHI scores were seen in patients >65 years old treated with RS, suggesting that these patients may specifically benefit from an early intervention.

Another study by Wagner and colleagues suggests that tumor size may influence the severity of vertigo [19]. In this study, DHI, caloric testing and hearing evaluation were performed in 38 patients with VS prior to microsurgery (22 patients) or CyberKnife® RS (16 patients). After a median of 50 days (time point 1) and 186 days (time point 2), these assessments were repeated. For analysis purposes, the researchers stratified patients according to pretreatment tumor size. Group 1 consisted of 21 patients with tumors <20 mm; the majority (14 patients) of this group were treated with Cyberknife RS. Group 1 patients reported more frequent vertigo attacks before treatment and benefited the most from therapy. Before treatment, 48% of group 1 patients reported vertigo attacks; after treatment only 10% reported them. Additionally, they showed a 10.5% improvement of vestibular function via caloric testing from baseline to second time point at 186 days. Group 1 DHI scores improved from baseline to second follow-up time point, correlating with an improvement in QOL.

By contrast, 22% of group 2 (patients with tumors >20 mm) reported vertigo before

treatment and 11% after treatment. Caloric testing revealed a 36% median improvement in vestibular function from baseline to second follow-up. However, DHI scores did not change significantly for this cohort of patients over a similar time interval. One would expect that as vestibular function dramatically improves, QOL would improve as well, but this did not occur in these patients. This suggests that other factors may play a role in determining the overall QOL experience. It should also be noted that DHI does not account for severity of symptoms and we can therefore only speculate whether patients with most severe vertigo would demonstrate greatest improvement in QOL.

■ Vertigo Symptom Scale

Another scale developed for peripheral vertigo is the VSS, which measures the severity and frequency of dizziness over a 12-month period. While the DHI assesses impact on QOL and level of disability, the VSS concerns the number and frequency of vertigo attacks; it consists of 22 questions [37]. Developed in the early 1990s by Yardley and colleagues, VSS highlights the psychological component of vertigo. One of the challenges in understanding the impact of vertigo on patients' lives has been the difficulty in accounting for patients' perception [4,38]. The patient's personality, associated symptoms and level of anxiety influence that perception. This could explain how studies showing patients' interpretation of their symptoms and level of disability (as measured by VSS and DHI) can correlate poorly with quantitative measures of vestibular dysfunction such as caloric testing [19,35,39].

The DHI and VSS have significant limitations. Neither is appropriately tailored to characterize vertigo symptoms in VS patients and neither has been validated in this setting. Furthermore, these scales do not address specific factors that can potentially worsen or improve symptoms. In addition to their general focus, the DHI and VSS are quite long and difficult to administer in a clinical setting. There is a clear need for a more clinically relevant and practical scale [5,28,40]. With such a tool, clinicians could consistently track vertigo symptoms before, during and after treatment. One of the challenges of acquiring vertigo data for VS patients has been that clinicians often do not ask about it. A new tool would encourage attention to these symptoms and highlight the fact that vertigo is

worth tracking in VS patients. Furthermore, any specific vertigo scale should be used in conjunction with a more general disease-specific symptom scale such as the Penn Acoustic Neuroma Quality-of-Life Scale [41], which provides a more global context of the patient's symptoms as they pertain to their VS.

Conclusion & future perspective

Improved vertigo data in VS patients could help answer the most basic questions: how many VS patients suffer from vertigo? What impact does that have on their QOL? What is the range of symptom severity? What is the best management of vertigo in patients with VS? Does RS or surgery improve vertigo? Does improving vertigo symptoms have an effect on a patient's QOL?

Current vertigo scales have a number of weaknesses. The most studied scale (DHI) does not distinguish between general dizziness and vertigo. The current literature on vertigo in VS patients highlights factors that could affect symptom severity, which could be incorporated into a new scale. Such factors include: patient demographics such as age; functional status; and tumor characteristics such as size and relationship to different components of the vestibular system. The scale also needs to be practical and easily administered since data suggest that vertigo symptoms evolve over a period of months to years. A method to design a central vertigo questionnaire could start by selecting questions from

already validated scoring tools such as the DHI and VSS. Combining aspects of the two scales and adapting them to VS patients would have the advantage of accounting for both the patient's perception of their vertigo and their symptom severity. Questions specific to QOL concerns could then be added. Finally, the scale would need to be cross-validated with caloric testing to ensure that physiological as well as psychological factors are considered in QOL calculations.

A series of small studies suggest that vertigo symptoms and corresponding QOL improve in VS patients after RS. Therefore, developing a scale to assess symptom severity may be particularly important for appropriate selection of patients for treatment. Furthermore, studies of RS dosimetry on vestibular function may then be possible. Given that vertigo can be significantly disruptive, evaluating treatment applications could help improve patients' long-term experience after RS and other interventions.

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References

Papers of special note have been highlighted as:

- of interest
 - of considerable interest
- 1 Karatas M. Central vertigo and dizziness: epidemiology, differential diagnosis, and common causes. *Neurologist* 14(6), 355–364 (2008).
 - 2 Colledge N, Barr-Hamilton R, Lewis S, Sellar R, Wilson J. Evaluation of investigations to diagnose the cause of dizziness in elderly people: a community based controlled study. *BMJ* 313(7060), 788–792 (1996).
 - 3 Chan Y. Differential diagnosis of dizziness. *Curr. Opin. Otolaryngol. Head Neck Surg.* 17(3), 200–203 (2009).
 - 4 Wilhelmsen K, Junggren A, Goplen F, Eide G, Nordahl S. Long-term symptoms in dizzy patients examined in a university clinic. *BMC Ear Nose Throat Disord.* 16(9), 2 (2009).
 - 5 Neuhauser H. Epidemiology of vertigo. *Curr. Opin. Neurol.* 20(1), 40–46 (2007).
 - 6 Solomon D. Distinguishing and treating causes of central vertigo. *Otolaryngol. Clin. North Am.* 33(3), 579–601 (2000).
 - 7 Baloh R. Differentiating between peripheral and central causes of vertigo. *J. Neurol. Sci.* 221(1–2), 3 (2004).
 - 8 Swartz R, Longwell P. Treatment of vertigo. *Am. Fam. Physician* 71(6), 1115–1122 (2005).
 - 9 Labuguen R. Initial evaluation of vertigo. *Am. Fam. Physician* 73(2), 244–251 (2006).
 - 10 Bird P, MacFarlane M. Management of unilateral vestibular schwannoma/acoustic neuroma. *N. Z. Med. J.* 120(1265), U2805 (2007).
 - 11 Humphriss R, Baguley D, Axon P, Moffat D. Preoperative audiovestibular handicap in patients with vestibular schwannoma. *Skull Base* 16(4), 193–199 (2006).
 - 12 Kentala E, Pyykko I. Clinical picture of vestibular schwannoma. *Auris Nasus Larynx* 28(1), 15–22 (2001).
 - 13 Matthies C, Samii M. Management of 1000 vestibular schwannomas (acoustic neuromas): clinical presentation. *Neurosurgery* 40(1), 1–9; discussion 9–10 (1997).
 - 14 Morrison G, Sterkers J. Unusual presentations of acoustic tumours. *Clin. Otolaryngol. Allied Sci.* 21(1), 80–83 (1996).
 - 15 Tufarelli D, Meli A, Labini F *et al.* Balance impairment after acoustic neuroma surgery. *Otol. Neurotol.* 28(6), 814–821 (2007).
 - 16 Baumann I, Polligkei J, Blumenstock G, Mauz P, Zalaman I, Maassen M. Quality of life after unilateral acoustic neuroma surgery

- via middle cranial fossa approach. *Acta Otolaryngol.* 125(6), 585–591 (2005).
- 17 Wackym P, Hannley M, Runge-Samuelson C, Jensen J, Zhu Y. Gamma knife surgery of vestibular schwannomas: longitudinal changes in vestibular function and measurement of the Dizziness Handicap Inventory. *J. Neurosurg.* 109(Suppl.), 137–143 (2008).
- **One of the first studies to describe changes in vestibular function after radiosurgery treatment of vestibular schwannomas.**
- 18 Myrseth E, Moller P, Pedersen P, Lund-Johansen M. Vestibular schwannoma: surgery or gamma knife radiosurgery? A prospective, nonrandomized study. *Neurosurgery* 64(4), 654–661 (2009).
- 19 Wagner J, Glaser M, Wowra B *et al.* Vestibular function and quality of life in vestibular schwannoma: does size matter? *Front. Neurol.* 2, 55 (2011).
- 20 Arthurs B, Fairbanks R, Demakas J *et al.* A review of treatment modalities for vestibular schwannoma. *Neurosurg. Rev.* 34(3), 265–277 (2011).
- 21 Whitmore R, Urban C, Church E, Ruckenstein M, Stein S, Lee J. Decision analysis of treatment options for vestibular schwannoma. *J. Neurosurg.* 114(2), 400–413 (2011).
- 22 Pollock B, Driscoll C, Foote R *et al.* Patient outcomes after vestibular schwannoma management: a prospective comparison of microsurgical resection and stereotactic radiosurgery. *Neurosurgery* 59(1), 77–85 (2006).
- 23 MacAndie C, Crowther J. Quality of life in patients with vestibular schwannomas managed conservatively. *Clin. Otolaryngol. Allied Sci.* 29(3), 215–218 (2004).
- 24 Duracinsky M, Mosnier I, Bouccara D, Sterkers O, Chassany O. Literature review of questionnaires assessing vertigo and dizziness, and their impact on patients' quality of life. *Value Health* 10(4), 273–284 (2007).
- **Reviews various available questionnaires for assessment of vertigo and dizziness complaints in patients.**
- 25 Godefroy W, Hastan D, van der Mey A. Translabyrinthine surgery for disabling vertigo in vestibular schwannoma patients. *Clin. Otolaryngol.* 32(3), 167–172 (2007).
- 26 Mira E. Improving the quality of life in patients with vestibular disorders: the role of medical treatments and physical rehabilitation. *Int. J. Clin. Pract.* 62(1), 109–114 (2008).
- 27 Myrseth E, Moller P, Wentzel-Larsen T, Goplen F, Lund-Johansen M. Untreated vestibular schwannomas: vertigo is a powerful predictor for health-related quality of life. *Neurosurgery* 59(1), 67–76 (2006).
- 28 Sandooram D, Grunfeld E, McKinney C, Gleeson M. Quality of life following microsurgery, radiosurgery and conservative management for unilateral vestibular schwannoma. *Clin. Otolaryngol. Allied Sci.* 29(6), 621–627 (2004).
- 29 Tamber A, Wilhelmsen K, Strand L. Measurement properties of the Dizziness Handicap Inventory by cross-sectional and longitudinal designs. *Health Qual. Life Outcomes* 7, 101 (2009).
- 30 da Cruz M, Moffat D, Hardy D. Postoperative quality of life in vestibular schwannoma patients measured by the SF36 Health Questionnaire. *Laryngoscope* 110(1), 151–155 (2000).
- 31 Tufarelli D, Meli A, Alesii A *et al.* Quality of life after acoustic neuroma surgery. *Otol. Neurotol.* 27(3), 403–409 (2006).
- 32 Lynn S, Driscoll C, Harner S, Beatty C, Atkinson E. Assessment of dysequilibrium after acoustic neuroma removal. *Am. J. Otol.* 20(4), 484–494 (1999).
- 33 Uehara N, Tanimoto H, Nishikawa T *et al.* Vestibular dysfunction and compensation after removal of acoustic neuroma. *J. Vestib. Res.* 21(5), 289–295 (2011).
- 34 Humphriss R, Baguley D, Moffat D. Change in dizziness handicap after vestibular schwannoma excision. *Otol. Neurotol.* 24(4), 661–665 (2003).
- 35 Jacobson G, Newman C. The development of the Dizziness Handicap Inventory. *Arch. Otolaryngol. Head Neck Surg.* 116(4), 424–427 (1990).
- 36 Lopez-Escamez J, Gamiz M, Fernandez-Perez A, Gomez-Finana M, Sanchez-Canet I. Impact of treatment on health-related quality of life in patients with posterior canal benign paroxysmal positional vertigo. *Otol. Neurotol.* 24(4), 637–641 (2003).
- 37 Yardley L, Masson E, Verschuur C, Haacke N, Luxon L. Symptoms, anxiety and handicap in dizzy patients: development of the Vertigo Symptom Scale. *J. Psychosom. Res.* 36(8), 731–741 (1992).
- 38 Tschan R, Wiltink J, Best C *et al.* Validation of the german version of the Vertigo Symptom Scale (VSS) in patients with organic or somatoform dizziness and healthy controls. *J. Neurol.* 255(8), 1168–1175 (2008).
- 39 Yardley L. Prediction of handicap and emotional distress in patients with recurrent vertigo: symptoms, coping strategies, control beliefs and reciprocal causation. *Soc. Sci. Med.* 39(4), 573–581 (1994).
- 40 Fielder H, Denholm S, Lyons R, Fielder C. Measurement of health status in patients with vertigo. *Clin. Otolaryngol. Allied Sci.* 21(2), 124–126 (1996).
- 41 Shaffer B, Cohen M, Bigelow D, Ruckenstein M. Validation of a disease-specific quality-of-life instrument for acoustic neuroma: the Penn Acoustic Neuroma Quality-of-Life Scale. *Laryngoscope* 120(8), 1646–1654 (2010).
- **Describes the University of Pennsylvania (PA, USA) instrument for assessing quality of life in patients with vestibular schwannomas.**