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Vestibular Prehabilitation—A Single UK Center Experience and Literature Review

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Abstract

Objectives To assess whether vestibular prehabilitation with intratympanic gentamicin is a useful preoperative adjunct in allowing for early mobilization and short length of stay in patients with vestibular schwannoma (VS).

Design Retrospective single-center study and literature review.

Setting Tertiary neurosurgical center.

Participants Adult patients undergoing surgery for VS.

Main Outcome Measures Our primary outcome measures were evidence of compensation following prehabilitation (defined as saccades becoming more covert and clustered on video head impulse testing—vHIT), length of stay, and days until mobilization. Secondary outcome measures were reduction in gain on vHIT following treatment as well as need for antiemetics postoperatively.

Results Ten patients have been treated at our center and the majority have shown preoperative reduction in gain and evidence of compensation on vHIT. Median time to mobilization was 1 day and modal length of stay was 6 days. We found the current evidence to be variable, with small sample sizes and significant variation in outcome measures used.

Conclusion Overall we have found that the use of vestibular prehabilitation enables early mobilization, shortened length of stay and appears to be a promising preoperative adjunct in this population. Further research and assessment with a multicenter prospective clinical trial is merited.

Keywords
- vestibular schwannoma
- prehabilitation
- gentamicin
- lateral
- skull base
- vestibular prehabilitation

Introduction

Surgical resection of vestibular schwannomas (VSs) can involve a variety of approaches including retrosigmoid, translabyrinthine, or middle cranial fossa. It is common for patients to experience symptoms such as severe nausea, vomiting, and vertigo postoperatively, and this is thought to be multifactorial. Patients undergoing operations via the posterior fossa will often experience these side effects as a direct sequalae of the surgical approach, but in those undergoing surgery for VS, there is the added impact of sudden loss

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of vestibular function which amplifies these symptoms. Patients therefore can suffer in terms of postoperative morbidity, resulting in longer time until mobilization, increased length of stay, and associated risk of hospital acquired infections, as well as an overall poorer quality of life.

Gentamicin is known for being a vestibulotoxic agent and the destructive properties were initially used in the treatment of Meniere's disease. It is administered via an intratympanic injection and was reported to be a potential adjunct in patients with cerebellopontine angle tumors by Magnusson et al in 2007.[1] It has been shown to reduce vestibular function[2,3] in a gradual and progressive fashion. This allows the patient to acclimatize to the change in vestibular nerve function and was therefore suggested as potential surgical adjunct in patients planned for surgery for VS.

Vestibular "prehabilitation" as a concept combines the use of staged intratympanic gentamicin injections as well as a home vestibular training program to allow patients to acclimatize to a more gradual reduction in their vestibular function prior to surgery. The training programs are individually designed to cater to each patients' current level of vestibular function and can be progressively adjusted in a staged fashion as function declines and the patient begins to compensate. As a result, the patient does not experience a sudden deterioration in function. Theoretically, this will reduce the postoperative symptoms of nausea, vomiting, and vertigo and allow for a smoother and quicker postoperative recovery.

Our study objectives were to identify whether our vestibular prehabilitation program was successful in achieving preoperative vestibular compensation as well as early postoperative mobilization and reduction in length of stay.

Methods

A single-center retrospective review was performed on adult patients undergoing prehabilitation prior to surgery for VS via a translabyrinthine approach from 2018 to 2022. Electronic records, case note review, and audiology diaries with video head impulse test results were analyzed. Preoperative patient demographics, tumor size, Koos grade, and response to gentamicin treatment were recorded. Postoperative length of stay, days to mobilization, and need for antiemetic treatment were recorded.

Following informed consent, patients are given two or three intratympanic gentamicin injections over a 3-week period with video head impulse testing (vHIT) assessments in between treatments (to determine efficacy and if a third injection is required). They are encouraged to carry out their personalized home training exercises three to five times per day throughout this period. The vHIT provides an objective measure of the underlying fast fiber function represented by the gain as well as the degree of compensation of the vestibulo-ocular reflex (VOR) the patient is experiencing, represented by saccadic activity. The number and location of the saccades can indicate the level of compensation as they can be shown to cluster and time lock as the VOR recovers and compensates for the changing underlying function/gain.

Strengthening the Reporting of Observational Studies in Epidemiology guidelines have been followed for reporting.

Results

Ten patients have undergone this treatment at our center. Mean age was 45.3 (range 26–65) with a 3:2 female to male preponderance. Nine patients were undergoing surgery for the first time, with one patient having had previous retrosigmoid approach to VS and subsequent recurrence on follow-up imaging. Despite previous surgery, vHIT confirmed remaining vestibular function in this patient. Average tumor maximum diameter was 26.7 mm (range 15–40) with the following Koos grades—1 ($n = 2$), 2 ($n = 2$), 3 ($n = 3$), and 4 ($n = 3$).

vHIT results were analyzed for response including a reduction in gain and for saccades becoming more covert and clustered, indicating treatment response with vestibular compensation. We found that three patients had a reduction in gain in all three semicircular canals, four had reduction in two canals, and three patients had a reduction in a single canal. The vHIT results and vestibular clinic diaries were reviewed to assess whether patients showed compensation. This was defined as saccades becoming more clustered and covert, as well as the vestibular scientists mentioning compensation in the clinic diaries. We found that eight (80%) of patients showed compensation following prehabilitation treatment, with one showing no change and the final patient being deemed to have already shown a significant degree of compensation prior to treatment (►**Table 1**).

Average length of stay was 8.2 days with a modal length of stay of 6 days. Two patients suffered a cerebrospinal fluid (CSF) leak and one a postoperative wound infection resulting in increased length of stay. Sixty percent of patients were able to be mobilized on day 1 postoperatively. Patients required on average two antiemetic agents postoperative for an average of 2 days.

Discussion

There is mixed evidence in the literature regarding vestibular prehabilitation with limited national or international guidelines for the treatment. We performed a literature review of the use of vestibular prehabilitation and postoperative recovery in VS surgical patients and analyzed seven relevant full-text articles.

The articles by Tarnutzer et al and Tjernström et al[2,3] provided proof of concept that we can reduce vestibular function with gentamicin treatment. Further retrospective work by Tjernström et al[4] looked at a cohort of 41 patients with VS and subdivided them into those with remaining vestibular function and those with a loss of function. Four patients with residual function underwent treatment with gentamicin, and they reported short- and long-term improvement in postural control in the intervention group.

The same group published a further retrospective study[5] with a larger group of 20 patients and found them to have better initial postoperative recovery as well as improved

Table 1 Patient and tumor baseline details and prehabilitation results

Patient	Sex	Age	Tumor size (mm)	LOS (d)	Mobilization (d postoperative)	Reduction in gain (no. of canals/3)	Compensation (covert, clustered saccades)	Complications
1	F	57	15	8	1	1	N[a]	
2	F	35	35	7		2	Y	
3	M	26	40	17	4[b]	2	Y	CSF leak
4	M	30	26	6	1	1	Y	
5	F	34	30	12	4	3	Y	Wound infection
6	F	52	22	6	1	3	Y	
7	F	65	25	6	1	2	Y	
8	M	56	35	4	3[b]	1	Y	
9	M	49	15	4	1	2	Y	
10 (redo)	F	49	24	12	1	3	N	CSF leak

Abbreviations: CSF, cerebrospinal fluid; LOS, length of stay.
[a]Patient felt to already show compensation on initial video head impulse testing (pretreatment).
[b]Patient operated on Friday and therefore did not have physiotherapy service over weekend.

adaptive capacity when tested for perturbed stance stability at 6 months postoperatively. A more recent article, however, by Fellman et al[6] found no difference in gait and dizziness functional outcome measurements between patients who has been treated with gentamicin and those who had undergone standard preoperative work-up.

Two prospective case–control studies equally present opposing conclusions, with the first finding improvement in postoperative recovery, improvement in contralateral vHIT, and reduction in length of stay in patients pretreated with gentamicin.[7] Hrubá et al also prospectively compared two groups with all patients undergoing intensive postoperative vestibular prehabilitation and only the intervention arm being pretreated with gentamicin. They found no difference between the groups and postulated that it may be the intensive vestibular training exercises which convey the benefit in this group of patients.[8]

VSs are relatively rare tumors, and therefore, the majority of studies performed are on a small, heterogenous group with variation in tumor size and residual vestibular function. Patient recovery after surgery is affected by many variables such as intraoperative complications, CSF leak, development of hospital acquired infections, as well as symptoms related to the sudden loss of vestibular function; therefore, there are many confounding factors. It is difficult to draw firm conclusions from the literature, particularly given that three of the articles found in our literature review are written by the same research group with some patient crossover and an inherent risk of bias. The outcome measures used, relating to dizziness and balance vary between the different studies, and this also makes it challenging to compare and draw firm conclusions.

The term "vestibular rehabilitation" is broad, and it is often ambiguous in the literature as to which exercises and instructions were given to patients and whether plans were personalized such as is done in our center. The current evidence supports a personalized rehabilitation plan with a smaller number of exercises to improve compliance.[9] If other centers have used a generic plan for all patients, then they may report poorer outcomes which could be secondary to patients not tolerating the exercises and therefore having poor compliance.

Another consideration is the time frame in which we administered the gentamicin and prehabilitation training program. Due to the surgical scheduling, the majority of our patients underwent treatment over a 3-week period; however, a longer timescale may allow for further compensation. There is limited evidence on the optimal duration for treatment, and further research is merited.

It is also important to acknowledge that the treatment requires multiple hospital attendances for the patients as well as mild pain while undergoing the intratympanic injections. While this may require time off work in the short term preoperatively, this could potentially be outweighed by the longer term benefits. Our cohort of patients was appropriately counseled by a multidisciplinary team as to what the treatment would involve as well as hospital visits involved to ensure fully informed consent was gained prior to commencing the treatment. All patients underwent the full course of injections as planned; therefore, we feel the pain and discomfort was minimal, and overall, it was well tolerated.

We acknowledge the limitations of this study due to the small sample size and lack of patient-reported outcome measures to assess patient experience; however, we have been able to show that with this treatment, patients can be mobilized early and overall length of stay can be shortened. We have been offering this treatment routinely in our VS patients since introduced in 2018, and we do not have a control group which is another limitation of the study. We also acknowledge the potential for bias, given that this treatment has become part of routine practice at our center.

With multidisciplinary collaboration, we feel that our prehabilitation treatment program could be easily replicated

in other skull base centers who already treat patients with VS.

Conclusion

From our single-center cohort, intratympanic gentamicin can be used as a safe and effective agent alongside a vestibular prehabilitation program. VSs are uncommon tumors, and therefore, it would be a difficult patient population to gather a large sample size. Further research is merited and would likely involve a randomized controlled trial which would need to be multicenter to enable adequate recruitment. Standardized outcome measures would be essential, and these should be pragmatic—based on function to enable them to be relevant to the patient's recovery and quality of life following surgery. Vestibular prehabilitation programs should also be personalized and staged, in line with the current evidence, to allow for patients to have maximum benefit preoperatively.

Conflict of Interest
None declared.

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