Is There a Difference in Hospital Stay between Patients undergoing Translabrynthine or Retrosigmoid Surgery for Vestibular Schwannoma Stratified by Tumor Size?

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Abstract

Objective To date, no European study has compared approach-specific outcome data in vestibular schwannoma (VS) surgery stratified by tumor size. We analyzed hospital length of stay (LOS), intensive therapy/high-dependency unit (ITU/HDU) LOS, and complications in patients undergoing VS surgery via the translabrynthine (TL) versus retrosigmoid (RS) approaches, stratifying for tumor size.

Design Prospective database undergoing retrospective review.

Setting Tertiary center.

Participants A total of 117 patients with VS undergoing TL ($n = 71$) or RS ($n = 46$) surgical resection from 2011 to 2016 were analyzed. Data including age, gender, surgical approach, tumor size, hospital, and ITU/HDU LOS and postoperative complications were evaluated.

Intervention(s) Therapeutic—VS surgery via either TL or RS approach.

Main Outcome Measure(s) LOS (hospital/intensive care unit).

Results Hospital LOS was significantly greater in patients undergoing the RS approach versus TL approach in VS between 31 and 40 mm (11 versus 7 days, $p < 0.0006$). The mean ITU/HDU LOS was greater in the RS group compared with the TL group (4.6 versus 1, $p > 0.05$). Reported complications were higher in the RS group ($n = 40$ versus 22). A post hoc analysis of the 31 to 40 mm group revealed no statistically significant difference in the American Society of Anesthesiologists grade or preoperative performance status.

Conclusions In our practice, in VS sized 31 to 40 mm patients stay 4 days longer post RS compared with TL surgery. This translates to £1600 extra per patient in the UK. Our data may inform decision-making during the skull base multidisciplinary team and the consent process to help decide the ideal operative approach for the patient.

Keywords

- ▶ vestibular schwannoma
- ▶ acoustic neuroma
- ▶ hospital length of stay
- ▶ ITU or HDU length of stay
- ▶ retrosigmoid
- ▶ translabrynthine

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Introduction

Vestibular schwannomas (VS) are benign tumors arising from the vestibular nerve's Schwann cells. With an incidence of 1.5 per 100,000 population, they are among the commonest intracranial tumors, reported as 8 to 10% of all tumors in some series.^{1,2} Symptomatology correlates with tumor size, and presenting symptoms classically include ipsilateral sensorineural hearing loss, tinnitus, and disequilibrium. Larger lesions may cause facial numbness and brainstem compression. The diagnosis of VS is made with magnetic resonance imaging (MRI) with gadolinium contrast.

Modern management options include conservative monitoring through serial imaging, stereotactic radiotherapy, and surgical intervention. In the United Kingdom, the most commonly performed surgical approaches for VS include the translabyrinthine (TL) and the retrosigmoid (RS) approach. The TL approach is essentially transpetrosal approach via a mastoidectomy and labyrinthectomy to expose the internal auditory meatus (IAM) and cerebellopontine angle (CPA). This results in total hearing loss, but a good exposure of the IAM and usually no cerebellar retraction. The RS approach (also known as the posterior fossa/suboccipital approach) exposes the CPA and offers the potential for hearing preservation. However, there may be risks associated with cerebellar retraction and brain stem dysfunction.

The choice of approach is based on a range of factors including size and location of the VS, experience of the surgical unit, and patient-specific factors including age, premorbid state, and hearing status. This is reflected in our skull base multidisciplinary team (MDT) comprising both neurosurgeons and ears, nose, and throat (ENT) surgeons working collaboratively to decide the ideal approach for each patient.

While studies exist comparing postoperative facial nerve function and hearing outcomes between approaches, less is known about patient outcomes such as length of stay (LOS). LOS is a simple, but useful metric while evaluating the health economics of an intervention, especially in today's health-care climate. When accurately predicted, it can increase the overall efficiency of hospital bed occupancy with associated financial advantages.³

One United States-based review concluded that TL surgery had lower risks of postoperative facial nerve injury, dysphagia, and dysrhythmia, but no difference in 30-day general complications or cerebrospinal fluid (CSF) leak repair rates.⁴ They however did not measure LOS. A separate US cost effectiveness analysis found a lower hospital (but not intensive therapy unit [ITU]) LOS in TL versus RS approach. This translated to higher costs in tumors less than 2 cm in size in their study.⁵

Beyond the economic implications, LOS is important from the patient's perspective, and such data are useful to clinicians. It is a common question asked during consultations in clinic and during the consenting process. Within the National Health Service (NHS), an increased LOS from a procedure translates to higher overall cost of the admission. Furthermore, patients who have a longer stay in hospital

may be at risk of hospital-related complications, such as infection and thrombosis. As tumor size is a known factor for prognosis affecting neurological outcome and complication rate,⁴ we hypothesized that tumor size is a key variable determining LOS and factored this into our research question.

Thus, our objective was to analyze approach-specific outcomes including LOS, ITU/high-dependency unit (HDU) LOS, and complications stratified by tumor size.

Materials and Methods

Patient Sample

We conducted a retrospective review of a prospectively collected electronic VS database of patients undergoing surgery at a tertiary skull base unit from 2011 to 2016. The surgeons were equally familiar with the RS and TL approaches based on over 4 decades of collective experience using both approaches in equal numbers. The decision regarding choice of surgical approach in preoperative skull base MDT meetings (comprising both ENT and neurosurgeons) was multifactorial comprising tumor-specific factors, such as size and location of the VS—particularly degree of extension into the IAM and patient-specific factors including age, premorbid state, and hearing status. A total of 126 patients were initially identified undergoing TL or RS surgery for VS. Three TL and six RS cases were excluded due to missing/incomplete data. The final sample comprised 117 patients—71 in the TL group and 46 in the RS group. All patient details were anonymized, and the electronic database was refined using Microsoft Excel.

The sample was separated into two groups based on approach (TL versus RS) and was stratified according to tumor size (mm). This data was interrogated for patient demographics, admission, and discharge date (via eCareLogic); surgical approach; size of lesion (mm, in CPA); extent of resection (total, near total, or subtotal); postoperative facial function (House–Brackmann [HB] scale); hospital LOS; ITU/HDU LOS; and immediate postoperative complications. The extent of resection was determined and coded by the operating surgeon. A total resection was defined as complete macroscopic resection of tumor. A near total resection was defined as over 95% of the tumor removal with subtotal resection defined as <95%.

Demographics

The mean age of the sample was 49.2 years (48.6 in TL patients and 50.3 years in RS patients). The male to female ratio was 1:1.3 and 1.2:1 in TL and RS patients, respectively.

VS Size

Tumor size was determined on gadolinium contrast-enhanced MRI by measuring the greatest diameter on a single axial T1 image in the CPA. Tumors were stratified into five groups of 10 mm intervals up to 50 mm for greater accuracy and comparison of subgroups. Overall, in the TL group, mean tumor size was 23.6 ± 9.3 mm and in the RS group, 34.9 ± 6.6 mm.

Complications

Complication data collected were those recorded at the time of surgery and during hospital stay and those noted during postoperative follow-up. These include cranial nerve deficits (trigeminal, trochlear, abducens, and facial nerve palsies), visual (diplopia and disconjugate gaze), bulbar symptoms, pseudomeningocele and CSF leak (conservative versus surgically managed), hydrocephalus requiring ventricular drainage, cerebellar syndrome, intracranial hemorrhage, seizures, wound infection, and medical complications including sepsis. The postoperative facial nerve function was evaluated using the HB scale. We report the immediate postoperative HB recorded during early postoperative review within 24 hours. Although HB scores were recorded longitudinally, further analysis of these scores was not the objective of our study.

Financial Data

We used the United Kingdom Department of Health statistics for the average daily cost of an NHS bed estimated at £400⁶ and the average daily cost of a neuro-critical care bed in our tertiary unit estimated at £650, dependent upon the level of monitoring and organ support required per patient.

Data Analysis

We employed descriptive statistics to define the samples concerned. For subgroup comparisons, Mann–Whitney *U* statistical testing was selected. Due to small sample sizes, no adjusted multivariable regression analyses were performed. The criterion for statistical significance was set at $p < 0.05$ two tailed. All statistical analyses were performed by Graph Pad PRISM (California, United States).

Results

Extent of Resection, Hospital, and ITU/HDU LOS

The key anatomical factor while deciding the approach was degree of extension into the IAM with equally difficult tumors excised by both the RS and TL approaches. In the TL approach, most underwent a near total resection (41.8%) compared with the RS group where subtotal resection was performed in 68.3% of cases (►Table 1). It is worth noting that no tumors <20 mm underwent the RS approach. In this subgroup of 30 patients all of whom who underwent the TL approach, 50% were due to patient preference; other reasons included irregular lesions in a patient with a history of lymphoma, enlarging cystic components to the lesion, tumor

Table 1 Extent of gross tumor resection in TL and RS approaches in our series

	TL		RS	
Extent of resection	<i>n</i>	%	<i>N</i>	%
Total	25	37.3	1	2.4
Near total	28	41.8	12	29.3
Subtotal	14	20.9	28	68.3

Abbreviations: RS, retrosigmoid; TL, translabyrinthine.

Table 2 Median LOS in days for patients undergoing TL and RS surgery

Tumor size	TL		RS		<i>P</i> value [†]
	Median (IQR)	<i>n</i>	Median (IQR)	<i>n</i>	
0–10 mm	6 (5.25–7.75)	8	–	0	–
11–20 mm	7 (7–8)	22	–	0	–
21–30 mm	7 (7–9)	31	8 (7–18)	19	0.274
31–40 mm	7 (6.25–7)	8	11 (9–20.5)	21	0.0006*
41–50 mm	8 (7–9)	2	9.5 (7.75–12.5)	6	0.5

Abbreviations: IQR, interquartile range; LOS, length of stay; RS, retrosigmoid; TL, translabyrinthine.

Note: Boldface denotes statistically significant values.

**p* value < 0.1

growth and poor hearing ± age, predominantly intrusive tinnitus, or vestibular symptoms.

While stratifying by tumor size, the median LOS was greater in the RS group for tumors between 21 and 50 mm. This trend was statistically significant in tumors sized between 31 and 40 mm ($p = 0.0006$) (►Table 2, ►Fig. 1).

The median ITU/HDU LOS for both TL and RS approaches across all tumor sizes was 1 day (►Table 3). The mean ITU/HDU LOS was also comparable (►Table 4); however, of note, in the 31 to 40 mm, it was 3.6 days higher ($p > 0.05$).

Cost Implications (31 to 40 mm Subgroup)

Given the average daily cost of an NHS bed estimated at £400,⁵ in VS tumors sized 31 to 40 mm, this amounts to an increased £1600 expenditure per patient undergoing RS compared with TL surgery. For the similarly sized tumors, with the average daily cost of a neurocritical care bed in our tertiary unit estimated at £650, this amounts to £2340 extra per patient undergoing RS compared with TL surgery, a clinically but not statistically significant result within our unit.

Fig. 1 LOS (in days) comparison for TL and RS surgery stratified by tumor size (mm). In tumors sized 31 to 40 mm, patients stayed 4 days longer ($p < 0.05$). LOS, length of stay; RS, retrosigmoid; TL, translabyrinthine.

Table 3 Median ITU/HDU LOS for patients undergoing TL or RS surgery

Tumor size	TL		RS	
	<i>n</i>	Median LOS	<i>N</i>	Median LOS
0–10 mm	8	1	0	–
11–20 mm	22	1	0	–
21–30 mm	31	1	19	1
31–40 mm	8	1	21	1
41–50 mm	2	1	6	1

Abbreviations: HDU, high dependency unit; ITU, intensive therapy unit; LOS, length of stay; RS, retrosigmoid; TL, translabyrinthine.

Table 4 Mean ICU/HDU LOS for patients undergoing TL or RS surgery

Tumor size	TL		RS	
	<i>n</i>	Mean LOS	<i>N</i>	Mean LOS
0–10 mm	8	1	0	–
11–20 mm	22	1	0	–
21–30 mm	31	1.1	19	1
31–40 mm	8	1	21	4.6
41–50 mm	2	m*	6	1

Abbreviations: HDU, high dependency unit; ITU, intensive therapy unit; LOS, length of stay; m, missing data; RS, retrosigmoid; TL, translabyrinthine.

Note: Boldface values denote group of interest (31–40 mm group).

* Missing data.

Complications

Overall from 2011 to 2016, the incidence of postoperative complications was higher in the RS compared with that in the TL group ($n = 40$ versus 22). Of note in the TL group, trigeminal nerve dysfunction ($n = 6$ versus 3) and CSF leak requiring surgical repair ($n = 5$ versus 2) were higher. In the RS group, the following were higher: visual complications ($n = 6$ versus 3), conservatively managed CSF leak/pseudomeningocele ($n = 4$ versus 1), hydrocephalus requiring external ventricular drainage ($n = 6$ versus 0), and cerebellar syndrome ($n = 3$ versus 0). The complications are outlined in ►Table 5.

The postoperative facial nerve function was evaluated using the HB scale (►Fig. 2). The HB grades of patients during the early postoperative assessment (within 24 hours) was recorded and was also stratified by tumor size.

Post Hoc Analysis

Given the significant finding of an increased LOS in the 31 to 40 mm subgroup, a post hoc analysis examined this group for any confounding variables (►Table 6). Despite the small numbers in this subgroup, we deemed a post hoc analysis pertinent, given this was the only tumor size with a statistically significant difference in LOS between surgical approaches. It was important to exclude that the groups differed significantly in demographics, American Society of Anesthesiologists (ASA) grade,

Table 5 Incidence of complications (2011–2016) in the postoperative period

Complication (<i>n</i>)	RS	TL
CN V dysfunction	3	6
Bulbar symptoms	5	4
Diplopia	3	2
Disconjugate gaze	1	0
CN IV	2	0
CN VI	0	1
Pseudomeningocele	2	1
CSF leak (conservative mx)	2	0
CSF leak (surgical mx)	2	5
Hydrocephalus (EVD)	6	0
Cerebellar syndrome	3	0
ICH	1	0
Seizure	0	1
Wound infection	1	0
Sepsis (medical)	3	2

Abbreviations: CN, cranial nerve; CSF, cerebrospinal fluid; EVD, external ventricular drain; ICH, intracranial hemorrhage; mx, management; RS, retrosigmoid; TL, translabyrinthine.

preoperative World Health Organization (WHO) performance status, and the size of lesion. We also sought to describe any differences in postoperative HB function, extent of resection, and complication rate.

Discussion

There are a multitude of studies in the VS literature examining the selection of treatment modality and comparisons between them in terms of complications.⁷ There is however a paucity of literature on the health economics of the surgical treatment of VS. This is particularly important given the increasing incidence of VS, partly due to greater access to MRI imaging and screening. Together with an aging population and economic implications of a publicly funded healthcare system like the NHS, we were interested in LOS data across tumor sizes in our VS series.

The main finding in this study is that in 31 to 40 mm-sized VS, median hospital LOS was 4 days greater in patients undergoing the RS approach (11 versus 7 days, $p = 0.0006$). This translates to £1600 pounds extra per patient undergoing the RS compared with the TL approach in this subgroup of patients. The ITU/HDU LOS did not differ significantly between groups. The increased hospital LOS is also a clinically significant finding. This size of tumor (31–40 mm) can be managed via either approach. The only difference between TL and RS in our series in the 31 to 40 mm is that the RS approach involves cerebellar retraction whereas the TL does not. Otherwise, there is surgical equipoise in terms of skill, tissue handling, and the surgical team doing the surgery. Whether cerebellar retraction alone accounts for the

Fig. 2 Postoperative facial nerve function (HB scores) in TL versus RS surgery, stratified by tumor size (mm). HB, House–Brackmann; RS, retrosigmoid; TL, translabyrinthine.

LOS difference is controversial. Postoperative acute vestibular dysfunction may be amenable to central compensation and equilibration. Although persisting disequilibrium has been reported in up to 43 to 78% of patients, one study concluded that greater cerebellar retraction in RS surgery does not result in greater long-term imbalance/disability compared with the TL approach.⁸

We performed a post hoc analysis of the 31 to 40 mm subgroup and did not find any significant differences in the age, gender, ASA grade, WHO performance status, or size of the lesions treated by each approach.

Regarding postoperative complications, we examined the two groups retrospectively and noted a higher overall incidence in the RS group. However, limited conclusions can be drawn from this finding given the numbers in the study.

To our knowledge, no study in Europe has looked at LOS stratified by tumor size and complications, comparing the TL and RS approaches. One US nationwide database review observed that there was no difference in 30-day general neurological or neurosurgical complications between

approaches.³ They found no significant difference in CSF leak repair rates, but TL surgery had lower risks of postoperative cranial nerve (CN) VII injury, dysphagia and dysrhythmia. However, they did not explicitly investigate LOS as a key variable. The study by the Cleveland group⁴ did consider LOS. They found that LOS was significantly lower in TL versus RS surgery (2.6 versus 4.3 days, $p < 0.001$) but not ITU LOS. Consequently, the adjusted mean total hospital cost was higher for RS versus TL surgery (\$25,069 versus \$16,799, $p < 0.001$ for lesions < 2 cm). It is notable that this trend of increased cost only held statistical significance for lesions < 2 cm. This may be explained by the fact that the TL route is favorable in smaller lesions i.e., < 20 mm given the greater exposure of the IAM compared with the RS approach. This reflects our naturally undertaken practice where no lesions under 2 cm underwent the RS approach.

Limitations

Our study was not randomized with the multi-factorial MDT decision-making, an area that could be evaluated in future

Table 6 Thirty-one- to 40 mm-sized VS: subgroup analysis

	TL (n = 8)	RS (n = 21)
Age (years)	52.1	47.4
M:F ratio	1:1.6	1.4:1
ASA grade	Mean: 1.38 Median: 1	Mean: 1.5 Median: 1
WHO performance status (preoperatively)	Mean: 0.75 Median: 1	Mean: 0.36 Median: 0
Size of lesion	Mean: 36.1 mm Median: 35 mm	Mean: 37.2 mm Median: 36.5 mm
Postop HB score		
HB I–II	75%	55%
HB III–I	25%	45%
Resection extent	1 total 2 near-total 5 sub-total	8 near-total 12 sub-total 1 abandoned 1 planned cyst drainage
Complications	2 (n = 8)	26 (n = 22)
Median LOS	7 days	11 days

Abbreviations: ASA, American Society of Anesthesiologists' Physical Status Classification System; HB, House–Brackmann Grading Score; LOS, length of stay; Postop, postoperative; RS, retrosigmoid; TL, translabyrinthine; VS, vestibular schwannoma; WHO, World Health Organization.

work. Our evolving ethos of subtotal/near total resection strategies for minimization of associated morbidity are not undertaken by all skull base units, particularly those without ready access to gamma knife radiosurgery. We cannot prove that the two groups were equally matched in terms of tumor consistency and degree of adhesions to the brainstem and facial nerve. Despite this, patients were matched demographically and in the post hoc subgroup analysis, ASA grade, and preoperative performance status.

Conclusion

The treatment strategy of VS has dramatically changed in the past 20 years with an increasing move toward watchful waiting and the use of stereotactic radiosurgery. Neverthe-

less, there are no guidelines in the United Kingdom or Europe on the best practice while choosing the most effective surgical approach—different strategies can be employed with similar outcomes. In our practice, in VS sized 31 to 40 mm, patients stayed 4 days longer while undergoing RS surgery compared with TL surgery. This translates to £1600 extra per patient in the United Kingdom. Data from our skull base unit's practice informs clinicians regarding the relationship between tumor size and LOS in VS surgery. Furthermore, expected LOS is frequently asked by patients during the consenting process. Although LOS is a complex variable to use in the final assessment of surgical outcome, the concept of reducing hospital LOS where possible for the benefit of the patient population is an important consideration in skull base surgery. We reiterate that a combined skull base surgery MDT approach with diverse surgical experience is best suited to decide the ideal approach for the individual patient, but hospital LOS may be a feature within this process.

Conflict of Interest
None.

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