Comparison of the surgical and follow-up costs associated with microsurgical resection and stereotactic radiosurgery for vestibular schwannoma

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Object. The best approach to the management of vestibular schwannoma (VS) remains controversial. The aim of this study is to analyze the initial and follow-up costs of resection and stereotactic radiosurgery for patients with VS.

Methods. Initial and follow-up costs in 53 cases in which patients with unilateral, previously unoperated VSs > 3 cm underwent resection (21 cases) or radiosurgery (32 cases) at the Mayo Clinic from June 2000 until July 2002 were analyzed for 36 months. Follow-up treatment-specific utilization records were gathered prospectively for patients not returning to the Mayo Clinic after treatment. Six-month moving averages of incremental follow-up costs were calculated for the 2 patient groups.

Results. The mean cost of surgery in the microsurgery group was $23,788 (95% confidence interval $22,280–$24,842) compared with $16,143 (95% confidence interval $15,277–$17,545) for the radiosurgical group. Mean incremental follow-up costs per month for patients in the microsurgery group started just > $1000 per month, decreased steadily, and remained < $70 per month by the 10th month of follow-up. Mean incremental follow-up costs per month for patients in the radiosurgical group were < $10 per month for the first few months and thereafter increased to as much as $200 per month.

Conclusions. Although the total cost of microsurgery is higher due to the costs of hospitalization, follow-up costs for radiosurgery are greater in general. From a societal perspective, radiosurgery is less expensive than microsurgical resection provided that the rate of tumor progression after radiosurgery remains low with long-term follow-up.

KEY WORDS • cost • follow-up • microsurgery • radiosurgery • vestibular schwannoma
The patients in the radiosurgery group tended to be older (53.9 years vs 48.2 years, p = 0.03) and live farther away from our center. There were no other substantive differences between patient groups at baseline. The mean follow-up period was 42 months (range 12–62 months). The current paper focuses on analyzing initial and follow-up costs for 53 patients in this group who participated in at least 36 months of follow-up.

In the initial study, comparison of the radiosurgery and resection subgroups showed that normal facial movement and preservation of serviceable hearing was more common in the radiosurgery group at 3 months (p < 0.001) and 1 year (p < 0.001) after treatment and at most recent follow-up (p < 0.01). Health status was assessed using a modified version of the 36-Item Short Form Health Survey. Three months after surgery, a significant decline in the following 4 subscales of this HSQ was documented in the patients treated with resection: physical functioning (p = 0.006), role–physical (p < 0.001), energy/fatigue (p = 0.02), and overall physical component (p = 0.004). Patients treated with resection demonstrated a persistent decline in the physical functioning (p = 0.04) and bodily pain (p = 0.04) subscales 1 year postoperatively, and in bodily pain (p = 0.02) at last follow-up. There was no posttreatment decline on any component of the HSQ in the patients treated with radiosurgery. In comparison with the patients treated with resection, the radiosurgery group had lower mean Dizziness Handicap Inventory scores (16.5 vs 8.4, p = 0.02) at last follow-up. There was no significant difference in the rate of tumor control between the patients treated with resection and those treated with radiosurgery (100% vs 96%, p = 0.50).

Data Collection and Analysis

All costs incurred during the surgical episode were grouped in one category and all subsequent costs were classified as follow-up costs. We analyzed the latter over a period of 36 months for each patient. For patients returning to the Mayo Clinic in Rochester, Minnesota, for follow-up medical care, detailed costs were gathered retrospectively using administrative databases. These costs encompassed all health care utilization charges incurred by these patients at the institution. Follow-up utilization records were gathered prospectively for patients not returning to the Mayo Clinic after surgery. These only included treatment-specific follow-up costs. We discounted all costs to the date of surgery at a continuous rate of 5%.

The duration of follow-up varied widely by patient; therefore, a minimum duration was chosen in order for a patient to be included in the analysis. Two cutoff points were chosen: 28 and 36 months. The cutoff points were chosen to include enough follow-up time to allow for possible recurrences for radiosurgery patients while at the same time minimizing sample attrition. Patient attrition from the sample is shown in Fig. 1. In this paper, we only report results for patients with at least 36 months of follow-up since there were no crucial differences in results between the 2 samples. Costs of utilization for patients not returning were imputed from existing data by matching these types of utilization with those for patients who did return for follow-up. This included the costs for follow-up MR imaging studies, audiograms, and later surgery for recurrent or progressive tumors.

Six-month moving averages of incremental follow-up costs were calculated for the 2 patient groups to smooth the variation in monthly data. Cost distributions were compared for the 2 groups using the Wilcoxon rank-sum and the Kruskal–Wallis tests.

Results

Initial Costs

For patients who underwent microsurgery and were followed up for ≥ 36 months, mean surgical costs were
$23,788 (95% confidence interval $22,280–$24,842). Similarly, the mean surgical costs for patients who underwent radiosurgery were $16,143 (95% confidence interval $15,277–$17,545).

Follow-Up Costs

We calculated median costs for each procedure performed in patients returning for follow-up to the Mayo Clinic and used these costs for the same procedures performed in patients who did not return for follow-up. These values are listed in Table 1. The largest portion of imputed costs came from follow-up MR imaging. One patient who did not return for follow-up underwent resection 35 months after radiosurgery. For both lengths of follow-up (28 and 36 months), the Wilcoxon rank-sum and the Kruskal–Wallis tests failed to reject the hypothesis of a difference between the costs for each group of patients (p = 0.432). (From a statistical standpoint, this means the variation in costs between radiosurgery and microsurgery cases was not large enough to conclude that the costs were drawn from different distributions; the observed differences could in fact be sampling variability.) Six-month moving averages of incremental follow-up costs for 36 months are shown in Fig. 2. Mean incremental costs per month for patients in the microsurgery group started just $1000 per month, decreased steadily, and stayed < $70 per month from the 10th month of follow-up on. Conversely, mean incremental costs per month for patients in the radiosurgery group were < $10 per month for the first few months and thereafter increased to as much as $200 per month.

Discussion

Comparing Approaches to VS Management

The philosophical and practical factors confronting patients when they have to decide between resection and radiosurgery for the treatment of VS are significant. Numerous comparative studies have repeatedly demonstrated that short-term CN outcomes are better in patients who undergo radiosurgery.\textsuperscript{14,20–23,26,32} Nonetheless, patients and their physicians still debate the relative merits of each approach due to a number of ongoing concerns. For example, should they choose a simpler, less-morbid technique that may be associated with a greater chance of tumor recurrence or a more invasive option that may provide an increased chance of “cure” of their benign tumor? If they undergo radiosurgery and it fails, will the tumor be more difficult to resect later?\textsuperscript{9,17} What is the chance of radiosurgery resulting in either malignant transformation of the VS or the development of a radiation-induced neoplasm?\textsuperscript{18} Despite these reservations, more patients undergo radiosurgery each year as the primary treatment for VS.\textsuperscript{21}

Equally important to patients is the effect of treatment on QOL. Studies have shown that more than half of patients who have undergone VS resection felt their QOL was worse after surgery,\textsuperscript{6} and only one third of patients resumed their normal activities of daily living within 1 month of their operation.\textsuperscript{5,21,32} The use of standardized instruments—such as the HSQ—to measure patient activities has also shown a significant decline in the physical functioning, role–physical, and social functioning components after VS resection, compared with published results obtained in controls.\textsuperscript{3,19} In contrast, radiosurgery has a less significant effect on QOL of patients with VS than resection does. Myrseth et al.\textsuperscript{20} used the 36-Item Short Form Health Survey\textsuperscript{35} to

![Fig. 2. Graph illustrating 6-month moving averages of incremental follow-up costs.](image-url)
The primary concern conducted was that the resection group suffered a significant decline in several components of the HSQ at 3-months, 1-year, and most-recent follow-up compared with their preoperative level of functioning, whereas the radiosurgery group showed no decline in any subset of the HSQ at any point during the follow-up period. These factors are appreciated by patients and their treating physicians and undoubtedly contribute to the increasing utilization of radiosurgery for the treatment of VS.

Similar to the effects on CNs and patients’ activities of daily living, the surgical and follow-up costs suggest significant differences between microsurgical resection and radiosurgery for the treatment of VS. The former entails high initial costs and negligible costs thereafter, whereas the latter is characterized by low initial costs followed by higher costs later on. Since the aim of radiosurgery is to arrest tumor growth rather than remove the tumor, there is always the chance of recurrence. The failure rate after VS radiosurgery has been reported to be ~ 3%. The primary concern is that earlier studies have reported on patients treated with radiation doses greater than the 12–13 Gy tumor margin dose commonly used today. Hasegawa et al. recently reported outcomes for 317 patients with VS who underwent radiosurgery between 1991 and 1998. The average tumor margin dose was 13.2 Gy. At a mean follow-up of 7.8 years, the 10-year progression-free survival rate for patients with tumors < 15 cm³ was 97%. Nevertheless, more data are needed on long-term tumor control with lower doses to conclude that tumor control rates achieved with radiosurgery and microsurgical resection are similar. For patients in whom radiosurgery fails, resection is typically recommended as salvage therapy, and these additional surgeries add significantly to follow-up costs. Friedman et al. conducted a matched control study in which they conclude that, although patients with prior irradiation for VS may have a more difficult surgery and poorer outcomes than those without, surgical time and complications do not differ among the 2 groups. Iwai and colleagues and others describe a general increased risk of CN damage following radiotherapy, but no other significant comorbidity. The available evidence leads us to conclude that, although surgery following VS may indeed be more difficult, there is no research documenting higher cost. Furthermore, follow-up medical appointments for MR imaging and audiograms tend to take place more frequently after radiosurgery than after surgical resection. In part, this relates to the relative newness of radiosurgery and the need to better characterize imaging and clinical outcomes of VS radiosurgery. Although in our study, patients undergoing radiosurgery tended to be older than those undergoing resection, and greater age may be associated with higher health care costs in general, we found that the primary reason for increased follow-up costs after radiosurgery was greater frequency of imaging and hearing evaluations. Last, because other health care utilization information is not available for many of these patients, the data represent, at best, lower bounds for actual costs.

We noted that younger patients more frequently underwent resection, which seems puzzling when we consider the potential loss of workdays and wages. Cho et al. retrospectively reviewed 174 cases in which patients with benign skull base tumors underwent open surgery or radiosurgery between 2000 and 2003. In their analysis, these authors found the major factor contributing to the increased societal cost of tumor removal was the indirect costs of workdays lost. The average number of workdays lost after resection was 160, compared with 8 after radiosurgery. Yet, given a positive chance of recurrence, younger patients may choose resection over radiosurgery if they are more averse to a recurrence over a longer period of time, whereas older individuals may rationalize that they may not live long enough for this difference to matter. On a related note, the true cost of either procedure includes the loss of productive time at work, the cost of formal and informal care in the recovery period, and similar unmeasured costs. We are not certain which procedure is likely to be associated with higher indirect costs; for example, younger patients may lose more productive work time but recover more quickly, whereas older patients may need more formal or informal care over a longer period of time.

Study Limitations

Our study was originally designed and powered to detect differences in patient outcomes (primarily CN function), not differences in costs. Thus, we did not have the ability to detect significant differences in follow-up costs with any level of certainty. Additionally, follow-up times of patients varied widely so we were forced to exclude patients with insufficient duration of follow-up. Another difficulty was the varying levels of completeness in the follow-up costs by surgery type. Since radiosurgery patients were more likely to live further away from our institution, they were also less likely to return for follow-up care. The only costs that could be imputed were from records specifically related to the initial surgery. The ideal situation would be to have all health care utilization costs for the entire follow-up period. For these reasons, the costs reported here represent lower bounds for the radiosurgery group.

Conclusions

Although the total cost of microsurgery is higher than that of radiosurgery due to the costs of hospitalization, follow-up costs for radiosurgery are in general higher than those for microsurgery, in part due to the nature of the radiosurgical procedure, the subsequent checkups, and the chance of recurrence. From a societal perspective, as long as the chance of recurrence is sufficiently low over a long enough period of time, radiosurgery is likely to be less expensive than resection due to the high total costs of the latter. If the chance of recurrence does not remain as low as is currently thought, it will not necessarily be clear which procedure is less costly. Long-term tracking of total health care utilization is needed to answer this question more conclusively.

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References


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