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Review

# Reporting success rates in the treatment of vestibular schwannomas: Are we accounting for the natural history?

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ABSTRACT

Stereotactic radiosurgery is generally accepted as one of the best treatment options for vestibular schwannomas. We question whether growth control is an accurate measure of success in vestibular schwannoma treatment. We aim to clarify the success rate of stereotactic radiosurgery and adjust the reported results to the benign natural history of untreated tumors. All articles were taken from a PubMed search of the English literature from the years 2000–2011. Inclusion criteria were articles containing the number of patients treated, radiation technique, average tumor size, follow-up time, and percentage of tumors growing during follow-up. Data were extracted from 19 articles. Success rates were adjusted using published data that 17% to 30% of vestibular schwannomas grow. The average reported success rate for stereotactic radiosurgery across all articles was 95.5%. When considering 17% or 30% natural growth without intervention, the adjusted success rates became 78.2% and 86.9% respectively. These rates were obtained by applying the natural history growth percentages to any tumors not reported to be growing before radiosurgical intervention. Success in the treatment of vestibular schwannomas with stereotactic radiosurgery is often defined as lack of further growth. Recent data on the natural growth history of vestibular schwannomas raise the question of whether this is the best definition of success. We have identified a lack of continuity regarding the reporting of success and emphasize the importance of the clarification of the success of radiosurgery to make informed decisions regarding the best treatment options for vestibular schwannoma.



## 1. Introduction

Vestibular schwannomas (VS), previously known as acoustic neuromas, are benign intracranial tumors arising from Schwann cells. These tumors occur with an incidence of 19.4 out of every 1,000,000 persons per year, a marked increase over the past few decades, most likely as a result of improved and more available imaging modalities [1]. VS are termed intracanalicular when they are confined to the internal acoustic meatus, and extracanalicular when they extend past the petrous portion of the temporal bone. Symptoms occur due to mass effect on the surrounding structures of the cerebellopontine angle, namely cranial nerves, the cerebellum, and the brainstem.

For many years, the natural history of VS was poorly elucidated, with growth rates varying between 18 and 85% [2–16]. Most of these studies were subject to various degrees of bias and all were relatively small, with an average number of only 88 patients (range 38–178). More recently, a large population-based prospective observational study demonstrated that a relatively small fraction of VS grow over several years of observation. In this study, Stangerup and colleagues demonstrated that only 17% of intracanalicular tumors grow, and only 30% of extracanalicular tumors grow. Furthermore, all of this growth occurs within the first 5 years following diagnosis [17].

Treatment of VS has shifted in recent years, moving away from the more invasive microsurgery toward stereotactic radiosurgical techniques. Radiosurgery is now generally accepted as one of the best management options for many patients with intracranial tumors, including VS [18]. Results from radiosurgery have often been reported as "lack of further growth" [19–25] or "tumor control rate" [26–31] without accounting for the predominantly benign natural history of these tumors. The aim of this study is to critically review articles published in the English literature in the last decade reporting outcome following radiosurgical treatment of VS and to determine if the natural history of these tumors has been accounted for in the reported success rates. For those studies

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where the natural history has not been taken into consideration, we provide a recalculated theoretical success rate, after accounting for the natural history data available at the time of writing.

## 2. Methods

This research was based on data gathered from the available scientific literature and did not involve patients or private health information. Therefore, no Institutional Review Board or Ethics Committee approval was required.

A PubMed search was conducted for English-language articles addressing stereotactic radiosurgical treatment of VS using the query "vestibular schwannoma stereotactic radiosurgery." Limits were placed to studies published in the last 10 years. This search yielded 356 articles from which appropriate publications were selected that included treatment outcomes with a distinct success rate reported. Articles that did not include number of patients treated, radiation technique, average tumor size, length of follow-up, and percentage (or number) of tumors growing during follow-up, were excluded. A total of 19 papers met the inclusion criteria and were statistically analyzed. Data collection was completed for each of the 19 articles. From each article, the following was identified: average size of tumors, dose and type of stereotactic radiosurgery (Gamma Knife [Elekta AB, Stockholm, Sweden], linear particle accelerator, proton beam, etc.), number of patients treated, reported number and percent of tumors growing pre-radiation, the defined criteria for growth, the number of tumors with growth not specified, reported number of tumors growing post-radiosurgery, the reported number of tumors with pseudoprogression, the reported success rate, and the definition of success. Data were entered into an Excel spreadsheet (Microsoft, Redmond, WA, USA) and simple formulas were used to carry out analysis.

Using these data, success rates were adjusted using the previously determined growth rate of both 17% (intracanalicular) and 30% (extracanalicular) of tumors growing, provided by the Stangerup et al. study. The total number of tumors theoretically growing was calculated by multiplying the number of tumors with "growth not specified" by 17% or 30%, then adding the total number of tumors growing pre-treatment (when provided). For example, if a study included 110 patients, with 10 tumors growing pre-radiosurgery, and 100 tumors not specified, the calculated number of tumors with theoretical growth would be $(0.17 \times 100) + 10 = 27$. The adjusted success rate was then calculated by dividing the reported number of tumors growing post-treatment by the number of tumors theoretically growing. In the example, if five tumors were growing post-radiosurgery, the reported success rate would be $(110 - 5)/110 = 95.5\%$. The adjusted success rate would be $(27 - 5)/27 = 81.5\%$. This mathematical analysis was performed for 18 out of the 19 articles, and a final adjusted success rate was calculated for both the 17% growth and 30% growth categories by averaging the success rates and adjusting for sample size. One paper was addressed separately because all of the patients had known tumor growth pre-treatment [32].

## 3. Results

A total of 2159 patients were included across all studies. Reported success rates following radiosurgery ranged from 87% to 100% [19–36] with an average reported success rate of 95.5% when adjusting for sample size. When considering a tumor growth percentage of 17%, the calculated adjusted success rate was 78.2% (range 25.4–100%), and assuming that 30% of tumors grow, the adjusted success rate was 86.9% (range 57.75–100%). Figure 1 shows the reported and adjusted success rates for each article.

## 4. Discussion

The management of benign tumors is influenced by quality of life and long-term control of tumor growth. The advantages of aggressive treatment and definitive cure must be balanced against tumor control and quality of life. In order to preserve the best quality of life possible, non-invasive treatments have gained increasing popularity because of the absence of open surgery, hospitalization, and general anesthesia. The trade-off of non-invasive treatments is often the inability to completely eliminate the tumor and success is often therefore defined as "lack of further growth" or "tumor control rate." In the field of VS surgery, radiation doses have been progressively reduced in an effort to minimize or eliminate side effects, including cranial nerve injury, facial palsy, and deafness.

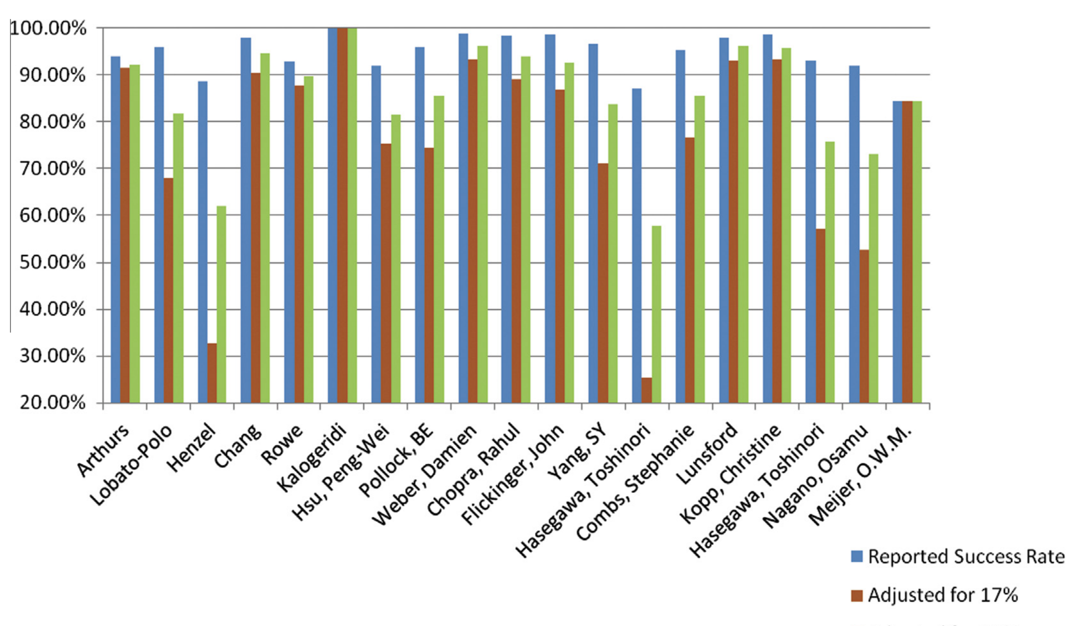


**Fig. 1.** The reported and adjusted success rates (for both 17% and 30% of tumors growing) for each article included in this review.