# The Long-Term Outcomes of Wait-and-Scan and the Role of Radiotherapy in the Management of Vestibular Schwannomas

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# The Long-Term Outcomes of Wait-and-Scan and the Role of Radiotherapy in the Management of Vestibular Schwannomas

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**Objective:** To analyze the growth characteristics in patients assigned to wait and scan in vestibular schwannomas (VSs) during long-term follow-up.
**Background:** The wait-and-scan policy and radiotherapy (RT) are conservative management strategies for VSs. A better insight into the natural history of the tumor and growth patterns is quintessential in planning optimal management.
**Methods:** The charts of 576 patients with unilateral sporadic VSs who were assigned to wait and scan at our center from 1986 to 2013 were reviewed. A systematic review of radiosurgical literature was done and compared with results of wait and scan.
**Results:** The overall mean follow-up was 36.9 ± 30.2 months. One hundred fifty-four patients with a 5-year follow-up were analyzed separately for patterns of tumor growth. Varied combinations of growth patterns were observed. Eighty-four (54.5%) tumors showed no growth throughout 5 years, 12 (7.8%) showed slow growth throughout 5 years, 2 (1.3%) tumors showed fast growth throughout 5 years. A total of 134 tumors (87%) showed favorable growth patterns for wait and scan. When the results of wait and scan were compared with those of RT, it pointed to the possibility that at least a portion of *control* of tumor by RT could be attributed to the natural course of the tumor.
**Conclusion:** The wait-and-scan modality is ideal for management of VSs in the elderly population and also in younger patients with intrameatal tumors. Considering the fact that a large percentage of tumors do not require any form of treatment, the role of RT in VSs needs to be reinvestigated.
**Key Words:** Long-term—Outcomes—Radiotherapy—Vestibular schwannomas—Wait and scan.
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Until the mid-1980s, there were only two well-defined modalities of treatment for vestibular schwannomas (VSs), namely, surgery and radiotherapy (RT) (1). In the following years, clinicians recognized that surgery or RT could be avoided in elderly patients because of the indolent growth pattern of these tumors, and such patients were managed with what came to be known as the wait-and-scan policy. At the same time, rapid technologic advances in neuroradiology made it possible to detect VSs early and map them accurately. The knowledge that most of the small tumors also did not show aggressive growth added to the indications for wait and scan. Today, the wait-and-scan modality, supported by serial imaging protocols with magnetic resonance imaging (MRI) that allows a systematic follow-up of tumors, has evolved considerably and is a well-accepted conservative treatment modality by itself for VS.

Predicting the behavior of tumor in wait and scan is complicated. But many wait-and-scan studies in the recent past have given an insight into the patterns of growth and tumor behavior. VSs have shown slow growth (SG), fast growth (FG), no growth (NG), involution (I), or a combination of these growth patterns. However, most series have shown that the majority of the tumors show no growth (2–4), ranging from 58% to 71% (5–10). Also, the overall success of this modality, as measured by the percentage of patients not requiring either surgery or RT, is between 66% and 92% (7,11–14). With this background, it is now necessary to review the reported results of RT in the treatment of VS wherein the benefits of RT

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could considerably overlap the natural course of the disease. In this study of a large group of 154 patients undergoing wait and scan for VS for a period of 5 years and above, we do an in-depth analysis of tumor characteristics and discuss the role of wait and scan and RT in the treatment of VS.

## MATERIALS AND METHODS

From December 1986 to May 2013, charts of 3, 547 VSs managed at the Gruppo Otologico (Piacenza-Rome), a quarternary referral center for skull base diseases and advanced otology in Italy, were reviewed. The following criteria were used to define the study population.

### Inclusion Criteria

Patients with a radiologic diagnosis of unilateral sporadic VS who were assigned to the wait-and-scan modality were included in the study population.

### Exclusion Criteria

Patients with neurofibromatosis (NF) Type II, unilateral sporadic VS with previous treatment, patients with inadequate radiologic and/or audiologic records, loss to follow-up, and patients with less than two serial MRIs were excluded from the study population.

The charts of patients in the study population were evaluated for demographic data, clinical features, radiology, tumor characteristics, growth features, and hearing outcomes. Age, symptoms including hearing status and vertigo, tumor size, and patient preferences played a role in delegating our patients to the wait-and-scan modality. The protocol followed to designate the patients into wait and scan is shown in Figure 1. Decision to adopt a particular modality was taken at this center in consultation with the patient and not by the referring physician. Risks and benefits of all the three options for the management of VS, namely, wait and scan, surgery, and RT were discussed with the patients and, thereafter, it was the patients' decision to proceed

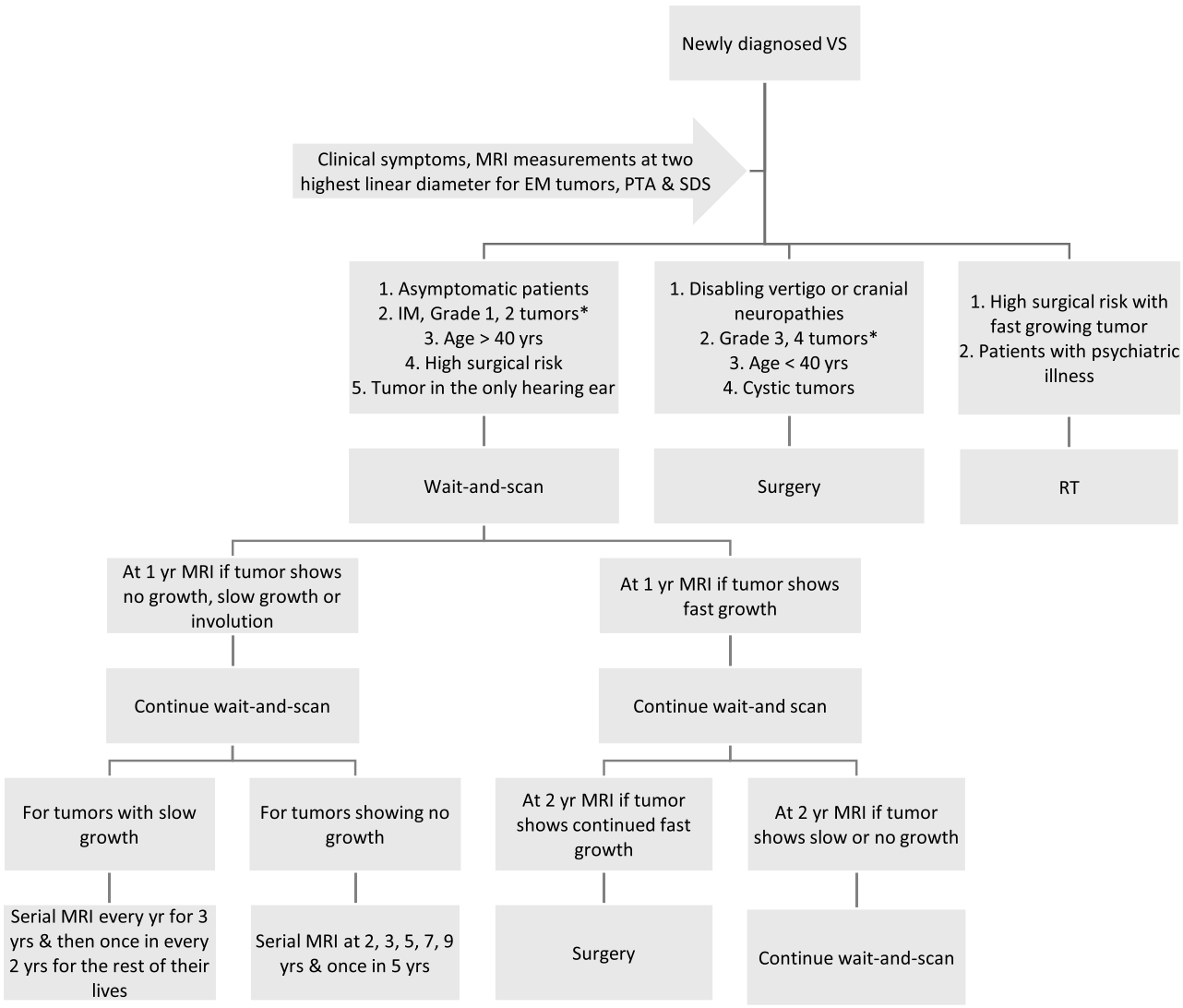


**FIG. 1.** Protocol followed at the Gruppo Otologico in the wait-and-scan modality.

with the wait-and-scan approach. The serial MRI protocols are also presented in Figure 1.

*Tumor size* was measured by linear measurements on MRI of the largest extrameatal (EM) diameter in two dimensions (Fig. 2). The tumors were then graded according to the article published by the Tokyo Consensus Meeting on Systems for Reporting Results in Acoustic Neuroma (15) into the following grades: Intrameatal (IM) tumor, Grade 1 tumor (1–10 mm EM tumor diameter); Grade 2 tumor (11–20 mm EM tumor diameter); Grade 3 tumor (21–30 mm EM tumor diameter); Grade 4 tumor (31–40 mm EM tumor diameter); and Grade 5 tumor (>40 mm EM tumor diameter, also called giant VS).

*Growth of tumor* was calculated as the difference in tumor sizes between the latest follow-up and the previous one that was recorded at each year of follow-up. *Growth* was defined as change in tumor diameter by 1 mm because anything less than this would be attributable to interobserver variation. Also, there exists the possibility of slight variations in scanning technique and image slice positioning that might have occurred from scan to scan that could play a role in limiting resolution of change in tumor size from MRI to MRI. When there was no recordable growth in a year, this was considered as no growth (NG). Growth less than 3 mm (a maximum of 2 mm) per year was considered as slow growth (SG), and 3 mm or more per year was considered as fast growth (FG). When there was a contraction in tumor size of 1 mm or more per year, it was considered as involution (I). For IM tumors, growth into the EM compartment was taken as growth.

### Review of Results of RT

A comprehensive search of peer-reviewed English language literature was done to identify studies that described tumor response in patients who underwent radiosurgery (RS) or fractionated stereotactic RT (FSR) as a treatment modality for VS from January 2000 to January 2013. Recent studies have shown that the two modalities have shown similar results vis-a-vis tumor control during long-term follow-up and hence are comparable (16,17). Reports that included a minimum of 100 cases were included. Hearing results were excluded from the analysis. For each included study, data were collected concerning the age and number of patients, treatment modality, previous treatment, prior policy of wait and scan, tumor size, tumor response, neurologic sequelae, follow-up, and toxicity.

### Statistical Analysis

The data were processed using SPSS version 21.0 statistics program (SPSS Inc., Chicago, IL, USA). The $\chi^2$ and Fisher's exact tests were used to compare nonparametric variables like tumor side, hearing status, initial symptoms, growth speciality, and sex data. Mean and SD were calculated for parametric variables, including patient age, tumor size, duration of follow-up, and parameters used for statistical analysis. The normality of the variables was analyzed by the Kolmogorov-Smirnov test. Independent-samples *t* test (in the case of normal distribution) or Mann-Whitney *U* test (in the case of non-normal distribution) was used to compare subgroups. Pearson test was used for correlation with *r* value. A value of $p < 0.05$ was considered statistically significant.

## RESULTS AND OBSERVATIONS

Of the 791 patients with VS who were assigned to the wait-and-scan protocol, 576 patients met the inclusion criteria. The overall mean follow-up was 36.9 ± 30.2 months. One hundred fifty-four patients who were followed up for 5 years or more were analyzed separately for tumor growth.

### Demography and Symptomatology

Of the study population of 576 patients, 262 (45.5%) patients were males and 314 (54.5%) were females (Table 1). The mean age of the patients was 59.2 ± 11.6 years (range, 20–89 yr). Forty-four patients (7.6%) were younger than 40 years, 231 (40.1%) were between 40 and 60 years, and 301 (52.3%) were older than 60 years, indicating a preponderance of an elderly population in the study group.

At the time of diagnosis, 211 (36.6%) of patients presented with serviceable hearing (Classes A and B) and 365 (63.4%) with unserviceable hearing (Classes C–F) according to the Modified Sanna classification. Ninety-four (16.3%) patients presented with sudden-onset sensorineural hearing loss (SNHL). The incidence of SNHL was higher in EM tumors than IM tumors. This difference is statistically significant. Vertigo and tinnitus were present in 137 (23.8%) and 46 (8%) of the patients, respectively.

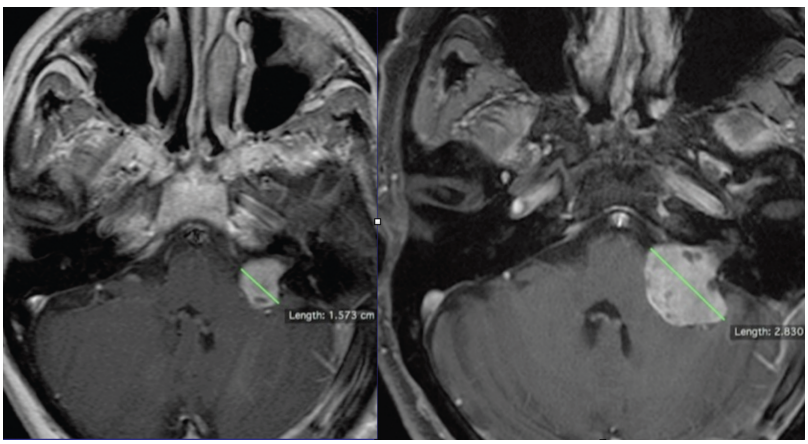


**FIG. 2.** MRI showing fast growth (12.57 mm growth in 1 yr) in a patient on wait and scan.

**TABLE 1.** *Relation between demography and clinical presentation of the study population*

| N = 576 | | n (%) | Sensorineural hearing loss, n (%) | | Vertigo/ imbalance, n (%) | Tinnitus, n (%) |
|---|---|---|---|---|---|---|
| | | | Serviceable hearing (Classes A, B) | Unserviceable hearing (Classes C–F) | | |
| Sex | Males | 262 (45) | 93 (35) | 169 (65) | 65 (25) | 17 (7) |
| | Females | 314 (55) | 118 (38) | 196 (62) | 72 (23) | 29 (9) |
| Age (yr) | 20–30 | 11 (2) | 4 (36) | 7 (64) | 4 (36) | 1 (9) |
| | 31–40 | 33 (6) | 15 (45) | 18 (55) | 8 (24) | 4 (12) |
| | 41–50 | 80 (14) | 47 (59) | 33 (41) | 27 (34) | 10 (13) |
| | 51–60 | 151 (26) | 59 (39) | 92 (61) | 33 (22) | 14 (9) |
| | 61–70 | 218 (38) | 70 (32) | 148 (68) | 46 (21) | 15 (7) |
| | 71–80 | 73 (12) | 14 (19) | 59 (81) | 17 (23) | 2 (3) |
| | 81–90 | 10 (2) | 2 (20) | 8 (80%) | 2 (20%) | — |

Tumor grades according to the Tokyo Consensus Meeting on Systems for Reporting Results in Acoustic Neuroma (15).

### Tumor Sizes (Grade) and Growth Rates

Of the 576 tumors at presentation, 333 (57.8%), 162 (28.1%), 80 (13.9%), and 1 (0.2%) were IM, Grade 1, Grade 2, and Grade 3 tumors, respectively. Four (0.7%) tumors were cystic.

The mean annual growth rate for the entire cohort was 1.21 ± 2.2 mm/yr. The mean annual growth rate for IM tumors was 1.07 ± 2.17 mm/yr and that for EM tumors was 1.40 ± 2.22 mm/yr, which was not statistically significant ($p = 0.142$). The mean annual growth rate of cystic tumors was 6.08 ± 3.10 mm/yr. In patients 40 years or younger and older than 40 years, the mean growth of tumor in the first year was 2.59 ± 3.8 mm and 1.2 ± 2.6 mm, respectively, and this difference was statistically significant ($p < 0.001$). Also, in the two groups, the mean growth of tumor in the first 2 years was 3.26 ± 4.2 mm and 1.67 ± 3.0 mm, respectively. This difference was also statistically significant ($p = 0.0022$).

*Patterns of Tumor Growth During Long-Term Follow-Up*

One hundred fifty-four patients with follow-up of 5 years and more were analyzed separately for patterns of tumor growth. Thirteen distinct patterns of growth were observed in our series (Table 2). Eighty-four (54.5%) of tumors showed NG throughout 5 years, 12 (7.8%) showed SG throughout 5 years, and 2 (1.3%) tumors showed FG throughout 5 years. The remaining 56 (36.4%) tumors showed mixed growth patterns, many of which were favorable for wait and scan (NG + SG, NG + I, NG + SG + NG, SG + NG, and SG + I). Overall, 134 tumors (87%) showed growth patterns favorable for wait and scan.

Growth was observed in nongrowing tumors as late as 5, 8, and 13 years of follow-up. All the four cystic tumors demonstrated FG at some point in time during follow-up.

*Relation Between Tumor Size (Grade) and Growth Patterns*

We analyzed the size of 154 tumors with a follow-up of 5 years and more to see if the tumor size had any consequence on growth patterns (Table 2; Fig. 3). Of the 95 IM tumors, 86% showed patterns favorable for wait and scan (excluding patterns involving FG), including 59 (62.1%) that showed NG throughout 5 years of follow-up. Of the 38 Grade 1 tumors, 87% showed patterns favorable for wait and scan, including 13 (34.2%) that showed NG throughout 5 years. Of the 20 Grade 2 tumors, 90% showed patterns favorable for wait and scan, including 18 (90%) that showed NG throughout 5 years. There was one

**TABLE 2.** *Relation between tumor growth patterns and tumor grade for a 5-year follow-up*

| n = 154 | | Grade of tumor at diagnosis, n (%)[a] | | | | | |
|---|---|---|---|---|---|---|---|
| | | IM tumors | Grade 1 tumors | Grade 2 tumors | Grade 3 tumors | Grade 4 tumors | n (%) |
| NG throughout 5 yr | | 59 (70) | 13 (16) | 12 (14) | — | — | 84 (54) |
| SG throughout 5 yr | | 7 (58) | 3 (25) | 2 (17) | — | — | 12 (8) |
| FG throughout 5 yr | | 1 (50) | 1 (50) | — | — | — | 2 (1) |
| Mixed growth patterns | NG + SG | 8 (57) | 4 (29) | 2 (14) | — | — | 14 (9) |
| | NG + FG | 7 (70) | 1 (10) | 2 (20) | — | — | 10 (7) |
| | NG + SG + NG | 3 (100) | — | — | — | — | 3 (2) |
| | NG + SG + FG | 1 (100) | — | — | — | — | 1 (1) |
| | NG + FG + NG | 1 (100) | — | — | — | — | 1 (1) |
| | NG + I | — | 3 (60) | 2 (40) | — | — | 5 (3) |
| | SG + NG | 5 (36) | 8 (57) | — | 1 (7) | — | 14 (9) |
| | SG + FG | 2 (33) | 1 (33) | — | — | — | 3 (2) |
| | SG + I | — | 2 (100) | — | — | — | 2 (1) |
| | FG + SG/NG/I | 1 (33) | 2 (33) | — | — | — | 3 (2) |
| Total | | 95 (61) | 38 (25) | 20 (13) | 1 (1) | — | 154 (100) |

NG indicates no growth; SG, slow growth; FG, fast growth; I, involution; IM, intrameatal.
[a]Tumor grades according to the Tokyo Consensus Meeting on Systems for Reporting Results in Acoustic Neuroma (15).

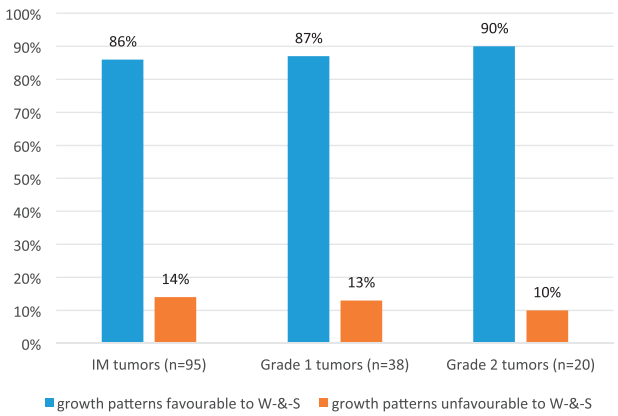


**FIG. 3.** Bar diagram showing the relation between tumor grade and growth pattern.

Grade 3 tumor, which showed slow growth in the first year of follow-up, followed by stability.

Thirty-two (20.7%) patients in the group of 154 patients with a 5-year follow-up and 150 (26%) in the main group of 576 patients failed wait and scan and were taken up for surgery.

## DISCUSSION

The natural history of VS may be variable. A proportion of tumors behave indolently, whereas another subset tends to show aggressive growth. The success of the wait-and-scan approach lies in identifying the right subset of patients and tumors that are most likely to grow in an indolent fashion and follow them up with strict imaging guidelines, thereby enabling the patients to escape any form of treatment. However, a failed wait and scan after a period could lead to difficult and unfavorable situations both for the doctor and the patient because of the problems of definitive treatment (surgery, RT) on a larger tumor, advanced age, and precipitation of symptoms.

Earlier studies that have reported on results of wait and scan have been hampered by many inconsistencies. These include short follow-up, faulty selection criteria, referral bias, variability in imaging modality and methods of estimating tumor sizes, differences in defining growth, and the inclusion of NF II, which have different tumor characteristics (6,9,18). However, during the last decade, thanks to the efforts of several surgeons, this has been corrected and many skull base centers across the world now have standardized wait-and-scan protocols. At our own center, based on our vast experience, we have formulated a policy of wait and scan (Fig. 1), which has proven to be effective, proof of which is the fact that, in our series, only 26% of patients failed wait and scan. The outcomes of wait and scan and the role of RT in VS are discussed below.

### Age

Unlike NF II in whom younger patients with VS have a higher growth rate, unilateral sporadic VSs have a tendency to afflict the older age group with a slower growth rate. As with our series, most studies investigating outcomes of wait and scan have a mean age of study population of approximately 60 years (6,7,10,11,19), which indicates that this modality is strongly indicated in the elderly population. This, along with the fact that our study showed that tumors grew at a slower pace in the elderly, indicates that the wait-and-scan policy is well suited for the elderly patients. However, a younger patient with an IM tumor can also be observed because these tumors have a tendency to demonstrate NG or other patterns of growth favorable to wait and scan.

### Tumor Growth Patterns

There may be some change in growth pattern from scan to scan, with some tumors appearing to change their growth pattern across time, and we observed 13 combinations of patterns of tumor growth in our series, as shown in Table 2. Tumors that do not grow during wait and scan are reported to be in the range of 45% to 75% (1,6,9,14,19,20). This variability may be caused by the different selection criteria adopted by authors for their patients. In our series, 54% of tumors showed NG, and an additional 32% showed patterns favorable to wait and scan (SG or a mixed pattern of SG/NG/I). Only 14% tumors showed events of FG during the 5-year follow-up. Also, 64% of tumors maintained a uniform growth pattern for 5 years, which makes the tumor growth fairly predictable. IM tumors reportedly have a higher tendency to show NG when compared with EM tumors (7,9,10,14,20), making them a suitable category for inclusion in the wait-and-scan modality. This was also confirmed in our study, wherein IM tumors predominantly showed favorable patterns like NG, SG, or involution (81 of 94 cases, 86.2%). Similarly, 33 (86.8%) of 38 Grade 1 tumors and 18 (90%) of 20 Grade 2 tumors demonstrated NG, SG, or involution. These findings of our study further reinforce the veracity of the previous study done by Battaglia et al. (14).

Cystic tumors are known to grow faster than solid tumors, sometimes showing spurts in growth (1). Therefore, such tumors must be followed up carefully and the surgeon must be willing to review the management in case of fast growth. Only four of the 145 cystic tumors in our series were assigned to wait and scan, and all of them showed evidence of fast growth during follow-up (21).

Studies have shown that the incidence and the rate of growth reduce across time, and some authors have even advised discontinuation of observation after 5 years (22–24). However, many recent studies including ours have demonstrated tumor growth after many years of follow-up (6,7). Hence, it is mandatory to continue wait and scan for life, although the interval between scanning can be reduced in nongrowing tumors. However, if one has a patient in their mid to late 80s with a small tumor that has been stable for several years, it is reasonable to offer scanning on an as-needed basis should new symptoms suggesting tumor enlargement occur.

**TABLE 3.** *Systematic analysis of studies of RT for VS in the last 10 years*

| Authors, yr | Modality | Sample size | Age (yr)[a] | Prior W&S/ selection criteria | Prior surgery (%) | Inclusion of NF II | Classification for tumor size | Tumor size[b] | Tumor response (%) | | | New VII nerve deficit (%) | New V cranial nerve deficit | FU[a] (mo) | Toxicity (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Regression | Stability | Progression | | | | |
| Hasegawa 2003 (48) | RS | 440 | 55 | NA | 21 | Incl | Koos[c] | 2.8 $cm^3$ | 59 | 34 | 7 | 2 | 0.5% | 150 | Intratumoral cyst formation (2%), Hhge (0.2%), rupture of VA aneurysm (0.2%), malignant transformation (0.2%) |
| Aoyama 2012 (49) | FSR | 201 | 55 | NA | 13 | 4% | NA | 20 mm | 79 | 21 | 3 | 2 | 72 | Hydrocephalus (12%) | — |
| Sun 2012 (50) | RS | 190 | 51 | NA | 30 | Excl | NA | 3.6 $cm^3$ | 64 | 25 | 11 | 1 | 3% | 109 | |
| Puataweepong 2013 (17) | RS/FSR/ CRT | 146 | NA | Yes, unclear | 61 | 9% | NA | NA | 87 | 13 | 1 | 1 | 61 | Hydrocephalus (1%) | |
| Lee 2012 (51) | RS | 221 | 54 | NA | NA | NA | NA | 3 $cm^3$ | 94 | 6 | NA | NA | 32 | Hydrocephalus (20%) | Hydrocephalus (4%) |
| Litre 2013 (52) | FSR | 158 | 53 | No | 8 | 5% | Koos[c] | 2.5 $cm^3$ | 51 | 47 | 2 | 3 | 4% | 60 | |
| Kapoor 2011 (53) | FSR | 385 | 54 | No | | | Arbitrary | 2.7 $cm^3$ | 67 | 33 | 2 | 3 | 56 | Hydrocephalus (1%), malignant transformation (0.5%) | |
| Kopp 2011 (54) | FSR | 68 | 56 | NA | 8 | 3% | Arbitrary | 1.2 $cm^3$ | 98 | 2 | — | 3 | 32 | NA | |
| | RS | 47 | 63 | | | | | 5.8 $cm^3$ | 99 | 1 | | | 30 | NA | |
| Timmer 2011 (26) | RS | 100 | 57 | Yes, unclear | NA | Excl | Tokyo[d] | 2.8 $cm^3$ | 95 | 5 | 1 | 1 | 38 | — | |
| Friedman 2006 (55) | RS | 390 | 62 | Yes, unclear | 21 | NA | NA | 2.2 $cm^3$ | 90 | 10 | 4 | 4 | 40 | NA | |
| Sawamura 2003 (31) | FSR | 101 | 53 | Yes, unclear | 12 | Excl | NA | 19 mm | 91 | 3 | 1 | 4 | 45 | Hydrocephalus (12%), vagal palsy (1%), brain edema (5%) | |
| Rowe 2002 (43) | RS | 234 | 56 | Yes, unclear | 25 | NA | NA | ~3.5 $cm^3$ | 38 | 54 | 8 | 1 | 6% | 35 | Hydrocephalus (1%), Intratumoral cyst formation (0.4%) |
| Prasad 2000 (56) | RS | 153 | 60 | No | 37 | Excl | NA | 2.8 $cm^3$ | 75 | 17 | 8 | 2 | 4% | 28 | NA |
| Our series, 2014 | W&S | 154 | 57 | Yes | No | No | Tokyo[d] | 8 mm | 4 | 54 | 42 | 0 | 0% | 60 | Hydrocephalus (1%) |

RS indicates radiosurgery; FSR, fractionated stereotactic radiotherapy; CRT, conventional radiotherapy; W&S, wait and scan; NF II, neurofibromatosis II; FU, follow-up; NA, not available; Incl, included; Excl, excluded; Hhge, hemorrhage; VA, vertebral artery.

[a]Mean or median as reported; [b]size in volume ($cm^3$) or diameter (mm) as reported; [c]Koos classification of VS (28); [d]Report of the Tokyo Consensus Meeting on Systems for Reporting Results in Acoustic Neuroma (15).

### Hearing and Facial Nerve Outcomes

A detailed discussion on the results of hearing and facial nerve outcomes in our series is beyond the scope of this article, and they will be published subsequently.

#### *Reporting in Wait and Scan*

Although there is no denying the fact that wait and scan is an effective modality in the treatment of VS, reporting of results in the future must eliminate discrepancies. The report of the Tokyo Consensus Meeting on Systems for Reporting Results in Acoustic Neuroma (15) has formulated rules for reporting on VS, which has been widely accepted and has proven to achieve standardization (25). NF II tumors must be kept out of reporting results of unilateral sporadic VS. A tumor showing a change in size of less than 3 mm between annual follow-ups can be considered as SG and 3 mm or more as FG. Until proper protocols for volumetric analysis of tumor growth are established, it is appropriate to measure tumors in the greatest linear diameter on MRI, which is also easily reproducible. Similarly, there is a convergence of the imaging and follow-up protocols used by our center and many others. Reduction of bias, development of consensus in reporting, and homogenization of wait-and-scan protocols need to be achieved as soon as possible.

#### *Review of the Role of RT in VS*

In the light of the fact that wait and scan has given us the opportunity to study the natural history of VS, which proves that a section of VS show indolent growth or do not grow at all, it is now important to review the results of RT (the term *RT* is used to include conventional RT, RS, or FRS) to find out if at least a portion of the success of RT can be attributed to the natural biology of the tumor itself. The literature on RT shows results in terms of tumor stabilization without taking into consideration pretreatment spontaneous arrest of growth (26). Very few authors reporting on the success of RT have emphasized on the policy of wait and scan to determine the natural progression of tumor, and many of their selection criteria have been arbitrary. Many reports lack consideration of age or size of tumors, which has a strong correlation to tumor growth. Moreover, inclusion of NF II, previously treated patients (surgery or RT), referral bias, variations in dose and the RT tool (RS or FSR), and short follow-up have added to the discrepancies of reporting of the results of RT. Most RT authors still report the size of the tumors and the hearing results according to old classifications like the Koos' classification (27) and the Gardner-Robertson's classification (28), respectively, instead of the newer and more comprehensive guidelines presented in the report of the Tokyo Consensus Meeting on Systems for Reporting Results in Acoustic Neuroma (15). A recent study by Han et al. (25) has observed that the guidelines have made a significant impact on standardization of reporting in RS.

A systematic analysis of the recent published literature on RS and FSR is compared with our wait-and-scan results in Table 3. It can be seen that most series on RT have an arbitrary approach to irradiation of tumors without a systematic selection criteria or wait-and-scan protocol before initiation of RT. Table 3 shows that all sizes of tumors have been irradiated. This also includes IM tumors that have shown to demonstrate an indolent growth pattern and for which wait and scan is recommended (19,29,30). It is well accepted that wait and scan is an ideal policy in the elderly age group with smaller tumors. The age of patients in our wait-and-scan series and RT series is the same, which indicates that many of the irradiated patients may have benefitted from wait and scan. If it were to be assumed that patients subjected to RT had tumors that showed prior growth, then it becomes important to define the rate of growth and the size of tumors that will prompt an initiation into RT, which is absent in most reports. For instance, tumors that show SG of 1 to 2 mm/yr in an elderly patient is not a matter of concern, and such patients can be included in wait and scan.

Also, RS is indicated in small tumors because of the high tumor dose, whereas FSR is indicated for larger tumors (31). But the comparisons show that RS has also been used for large tumors. The maximum and minimum size of tumors that can be irradiated is yet to be defined. On the other hand, studies have stated that microsurgery is better than RT for tumors larger than 2.5 cm (32–37) because of increased morbidity with RT in such cases (35,38–41). Other discrepancies in reporting like including patients with previous surgery, NF II, improper classification of tumor sizes, and short follow-ups diminish the validity of reports. The definition of tumor control is also highly variable between series, with some claiming *no additional surgical intervention* to mean tumor control, which is incorrect (42–47). As mentioned earlier, our wait-and-scan series shows that a tumor shows NG in 54%, regression in 4% (total of 58%), and progression in 42% of tumors (of which 28% showed SG). Compared with this, the successes of RT range from 79% to 99%. If this were to be reasoned with our wait-and-scan results, it could be inferred that between 21% and 41% of the tumors actually could have benefitted from RT.

For the benefit of the patient, both the surgeons and the radiotherapists have to be willing to apply the policy of wait and scan to suitable patients before subjecting them to definitive treatment. Once this commonality is achieved, the efficacy of RT with respect to microsurgery can be then compared among the subsets of patients who are not suitable for wait and scan or those who have failed wait and scan. This must be the direction of future studies that will enable us to draw meaningful conclusions. Also, standardized reporting criteria as suggested by Battaglia et al. (14) are recommended.

## CONCLUSION

Although the fate of unilateral sporadic VS, once detected, cannot be accurately predicted, reports of wait and scan have pointed toward certain trends in its

behavior. The wait-and-scan modality is ideal for management of VS in the elderly population and in younger patients with IM tumors. Fifty-four percent of the tumors in our series showed no growth, and a further 26% of tumors showed growth patterns favorable to wait and scan like SG or a mixture of SG/NG. Considering the results of wait and scan, which shows that a large percentage of tumors do not require any form of treatment, the role of RT in the treatment of VS needs to be reinvestigated. All VSs need to be followed up lifelong because many studies including ours have shown tumor growth very late during follow-up.

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