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Volume Changes After Stereotactic LINAC Radiotherapy in Vestibular Schwannoma: Control Rate and Growth Patterns

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Summary

A validated volume measuring tool with a calculated measurement error has, to our best knowledge, not been used before to evaluate control rates of vestibular schwannomas after treatment with LINAC based stereotactic radiotherapy. This retrospective study showed that the actual tumor response was lower compared with studies evaluating responses two-dimensionally; this effect is attributed to the use of the more sensitive volume measurements. The number of patients needing additional intervention was similar compared with earlier studies.

Purpose: The purpose of this study was to evaluate the control rate of vestibular schwannomas (VS) after treatment with linear accelerator (LINAC)-based stereotactic radiosurgery (SRS) or radiotherapy (SRT) by using a validated volumetric measuring tool. Volume-based studies on prognosis after LINAC-based SRS or SRT for VS are reported scarcely. In addition, growth patterns and risk factors predicting treatment failure were analyzed.

Materials and Methods: Retrospectively, 37 VS patients treated with LINAC based SRS or SRT were analyzed. Baseline and follow-up magnetic resonance imaging scans were analyzed with volume measurements on contrast enhanced T1-weighted magnetic resonance imaging. Absence of intervention after radiotherapy was defined as “no additional intervention group, ” absence of radiological growth was defined as “radiological control group. ” Significant growth was defined as a volume change of 19.7% or more, as calculated in a previous study.

Results: The cumulative 4-year probability of no additional intervention was 96.4% ± 0.03; the 4-year radiological control probability was 85.4% ± 0.1). The median follow-up was 40 months. Overall, shrinkage was seen in 65%, stable VS in 22%, and growth in 13%. In 54% of all patients, transient swelling was observed. No prognostic factors were found regarding VS growth. Previous treatment and SRS were associated with transient swelling significantly.

Conclusions: Good control rates are reported for LINAC based SRS or SRT in VS, in which the lower rate of radiological growth control is attributed to the use of the more sensitive volume measurements. Transient swelling after radiosurgery is a common phenomenon and should not be mistaken for treatment failure. Previous treatment and SRS were significantly associated with transient swelling. © 2012 Elsevier Inc.

Keywords: Vestibular schwannoma, Radiosurgery, Volume measurements, Growth control

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Conflicts of interest: none.

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Introduction

A vestibular schwannoma (VS) is a benign tumor originating from the Schwann cells of the 8th cranial nerve. Incidence is increasing, mostly due to aging of the population and increasing use and improvement of magnetic resonance imaging (MRI) (1).

Three main treatment modalities exist in VS management: a so-called "wait and scan" (W&S) policy, in which audiovestibular symptoms are monitored regularly combined with sequential MRI to follow VS growth, microsurgery, or stereotactic radiotherapy (2). The latter has proven to be a well-established and safe alternative to microsurgery for small- and medium-sized VS, with lower morbidity and similar rates of VS control (3).

Many studies reported on control rate after radiotherapy for VS. An important limitation of these studies is that measurements are mostly based on two-dimensional (2D) (2, 4−31) instead of volume measurements (31−38), and are therefore not ideal in assessing VS growth precisely (39). Another limitation is that these 2D studies use arbitrary growth criteria of 1 or 2 mm (2, 5, 6, 10, 13−16, 20, 25, 27) or do not even mention these growth cutoff points (4, 9, 11, 12, 17, 19, 21, 22, 26, 28, 30, 31, 40). According to a previous study, these cutoff points lie within the measurement error (39), making the results of these studies questionable. Two articles used volume measurements after linear accelerator (LINAC) radiosurgery (33, 35). The control rate of VS after LINAC stereotactic radiosurgery (SRS) or radiotherapy (SRT) was reassessed in this study by using a more precise assessment of VS growth with a validated volumetric measuring tool and previously defined growth cutoff points for this technique (39). Furthermore, growth patterns were analyzed and risk factors predicting post-radiosurgical VS growth were assessed.

Methods and Materials

Patient characteristics

Patients who received LINAC based SRS or SRT for a VS between February 2003 and March 2008 in the department of the Maastricht Radiation-Oncology (MAASTRO-clinic), Maastricht University Medical Center, were analyzed retrospectively in this study, resulting in 40 patients. One patient with neurofibromatosis type 2 was excluded. Two patients were excluded because they had only one follow-up (FU) MRI. Thirty-two patients were irradiated as primary treatment after being followed in a W&S policy. Seven patients received radiotherapy after subtotal VS resection. Histopathological examination showed VS in 5 patients. Two cases appeared to be a meningioma, for which they were excluded from this study. Therefore, the final analysis was based on 37 patients. Because this study was an analysis of radiological data, we did not include clinical FU parameters routinely for all patients. Clearly, in cases in which additional treatment was necessary, both radiological progression and clinical symptoms were taken into account and, if present, included in the present study.

SRT

All patients were treated with LINAC-based stereotactic radiotherapy. SRT was given either in a single session (SRS) or in a fractionated manner (SRT). Seventeen patients received SRS with 12 or 12.5 Gy prescribed to the 80% isodose line covering the VS margin. The other 20 patients received fractionated SRT with 30 fractions of 1.8 Gy to a total dose of 54 Gy (Table 1). SRT was prescribed to the 100% according to International Commission on Radiation Units and Measurements guidelines (41). The technique of stereotactic radiotherapy has been described in detail previously (42). Indications for LINAC based SRS or SRT were mainly clinical and/or radiological progression of the VS, postoperative radiotherapy to avoid further progression, or primary irradiation in case of comorbidity. SRS was applied in general when the VS was smaller than 2 cm in largest diameter, had no close contact to the brainstem, or if useful hearing was absent. In case of larger VS, the presence of (close, <2 mm) contact to the brainstem as well as the presence of useful hearing on the side of the VS, fractionated SRT was chosen. Patient-related factors as old age, comorbidity, or long travel distance were indicators for SRS.

Follow-up (FU)

FU was performed with a first MRI scan 3 months after SRS/SRT (baseline scan) and yearly thereafter until 5 years after treatment. Thereafter, once every other year, scans are performed until at least 10 years of FU are reached. In case of radiological progression or clinical symptoms, a more frequent FU was used. A total of 205 scans were available for analysis.

Methods

MRI sequences included 1- or 2-mm thick contrast-enhanced T1weighted images (CE-T1 WI). The volume measurements were performed on on axial coupes, using a computer system fitted with specialized software: iPlan® RT-Image version 4 (BrainLab Oncology Solutions, Feldkirchen, Germany). By tracing the VS surface on all slices, the software was able to provide the VS volume by using the slice interval. Segmentation results were checked visually. Measurements typically took a few minutes. VS characteristics were noted: central nonenhancement was defined as a hypointense mass in the center on CE-T1 WI. Cystic VS was

Table 1 Patient and vestibular schwannoma characteristics ($n = 37$)

Patient or vestibular schwannoma characteristic	Number (%)
Sex	
Male	16 (43)
Female	21 (57)
Mean age (yr)	61.6
Range	37−81
Side	
Left	22 (59)
Right	15 (41)
Radiotherapy	
Single	17 (46)
Fractionated	20 (54)
Follow up (months)	
Median	40
Range	16−79.5
Previous microsurgery	5 (14)