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Original Article

Linear Accelerator Stereotactic Radiosurgery for Vestibular Schwannomas: A UK Series

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Abstract

Aims: To evaluate non-auditory toxicity and local control after linear accelerator stereotactic radiosurgery (SRS) for the treatment of vestibular schwannomas.
Materials and methods: The institutional policy was to use SRS for radiologically progressing vestibular schwannomas. Case notes and plans were retrospectively reviewed for all patients undergoing SRS for vestibular schwannomas between September 2002 and June 2012. All patients were surgically immobilised using a BrainLab stereotactic head frame. The treatment plan was generated using BrainLab software (BrainScan 5.03). The aim was to deliver 12 Gy to the surface of the target with no margin. Patients with a minimum of 12 months of follow-up were included for toxicity and local control assessment. Radiological progression was defined as growth on imaging beyond 2 years of follow-up. Overall local control was defined in line with other series as absence of surgical salvage.
Results: Ninety-nine patients were identified. Two patients were lost to follow-up. After a median follow-up interval of 2.4 years, the actuarial radiological progression-free survival at 3 years was 100% and overall local control was also 100%. However, two patients progressed radiologically at 3.3 and 4.5 years, respectively. Twenty-one of 97 (22%) evaluable patients suffered trigeminal toxicity and this was persistent in 8/97 (8%). Two of 97 (2%) suffered long-term facial nerve toxicity (one with associated radiological progression causing hemi-facial spasm alone). One of 97 (1%) required intervention for obstructive hydrocephalus. No statistically significant dosimetric relationship could be shown to cause trigeminal or facial nerve toxicity. However, 7/8 patients with persistent trigeminal nerve toxicity had tumours in contact with the trigeminal nerve.
Conclusions: SRS delivering 12 Gy using a linear accelerator leads to high local control rates, but only prospective evaluation will fully establish short-term toxicity. In this study, persistent trigeminal toxicity occurred almost exclusively in patients whose tumour was in contact with the trigeminal nerve.

Key words: Acoustic neuroma; radiosurgery; vestibular schwannoma

Introduction

Vestibular schwannoma, also termed acoustic neuroma, is a Schwann cell-derived benign tumour arising from the vestibular component of the eighth cranial nerve. Although unilateral in over 90% of cases, bilateral tumours are found in association with type 2 neurofibromatosis [1]. Vestibular schwannoma is usually diagnosed on magnetic resonance imaging (MRI) carried out routinely for unilateral sensorineural deafness. Although a slow-growing tumour, a progressive increase in size can cause trigeminal and facial neuropathies, as well as brainstem compression with resultant obstructive hydrocephalus.

The management strategies for vestibular schwannoma include observation with serial imaging, surgical resection and radiotherapy (both fractionated and single fraction). The purpose of radiation treatment is two-fold; first to prevent growth in order to avoid surgery (local control) and second to preserve function. However, it remains unclear whether earlier intervention with radiation has any actual clinical benefits compared with observation. The term stereotactic radiosurgery (SRS) is often used to define single-

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fraction high-dose radiotherapy delivered with stereotactic localisation. Widespread reports of high local control rates (predominantly using gamma knife), have established SRS as the favoured approach [2–11]. SRS can also be delivered using a modified linear accelerator and a stereotactic surgical head frame providing necessary quality assurance tests are carried out. For example, tests include checks of mechanical and radiation alignment of the secondary collimator mount (a Winston-Lutz test), checks of rotational dosimetric output and small field dosimetric measurements to enable treatment planning [12].

Although publications support the use of SRS for vestibular schwannoma, prospective trial data are lacking and linear accelerator SRS publications remain limited. The purpose of this study was to evaluate clinical and dosimetric outcomes using linear accelerator-based SRS and to explore factors that may predict non-auditory toxicity.

Materials and Methods

Sequential patients treated with SRS for unilateral vestibular schwannoma at the Queen Elizabeth Hospital, Birmingham between September 2002 and June 2012 were prospectively recorded on a database. A retrospective review of clinical notes and treatment plans was carried out. Collected data included baseline patient characteristics, indication for radiosurgery, treatment-related toxicity (particularly facial and trigeminal neuropathies) and local control. Patients were followed up by the referring surgical team and MRI was carried out annually for 5 years after SRS as per local protocol.

Facial nerve function was classified using the House-Brackmann scale, and trigeminal toxicity was defined as any new post-SRS facial sensory change or pain, irrespective of the presence of objective physical signs [13]. Cranial neuropathies were subsequently classified as transient or persistent. Neuropathy was defined as persistent if present in two or more separate clinical reviews including the most recent, with a minimum interval of 4 months between reviews.

Tumour control was defined in two ways. Local control was defined in line with other series as the absence of surgical salvage and radiological failure as growth on imaging beyond the second year of follow-up [7,9,14].

Patients were censored at the date of most recent MRI. Absence of surgical salvage and radiological progression-free survival were calculated using the Kaplan–Meier method. For statistical analysis, Fisher's exact test, Student's *t*-test and the Mann–Whitney test were used to evaluate differences between groups.

Radiosurgical Technique and Plan Evaluation

All patients were treated on a 6 MV linear accelerator (Elekta 75-5 from 2002 to 2007 and a Varian 600C from 2007) with an externally mounted SRS collimator. The plan was generated by BrainLab software (BrainScan 5.03). External collimators were BrainLab fixed cones, ranging from 10 to 30 mm in diameter, measured at the machine isocentre of 1000 mm source to target distance. Delivery was via non-coplanar arcs of nominally 100 degree lengths, with typically three to four arcs per isocentre. Multiple isocentres (up to three) were used to achieve maximum conformality of the dose distribution to the surface of the tumour. The dose per arc was between 5 and 10 monitor units per degree, with a dose rate of 600 monitor units/min. Alignment of the radiosurgical beam to the axis defined by the room lasers was confirmed to be within 1.0 mm before each treatment delivery.

Gadolinium-enhanced MRI (T1-weighted, 1.25 mm slice thickness, 1.5T) was obtained before treatment for the purpose of radiosurgery planning. A BrainLab stereotactic head frame was attached to the skull under local anaesthesia to enable immobilisation. Subsequent stereotactic computed tomography was co-registered with the volumetric MR images. Tumour as shown on gadolinium-enhanced MRI was defined as the planning target volume (PTV). A dose of 12 Gy was prescribed to the periphery of the PTV (marginal dose). A maximum dose of up to 24 Gy was accepted within the PTV when using three isocentres. The brainstem objective was set at a maximum point dose of 12.5 Gy. Patients received a 2 or 3 day course of oral dexamethasone 8 mg daily starting on the day before SRS, to reduce the risk of acute swelling of the tumour.

Plans were retrospectively reviewed with the aim of collecting dosimetric data, including the number of isocentres, tumour volume, maximum point dose and maximum dose to brainstem and trigeminal nerve. If necessary, further organs at risk were contoured. The trigeminal nerve was defined from where it becomes visible leaving the brainstem to the petrous ridge. The Radiation Therapy Oncology Group conformity index, gradient index (volume of half the prescription isodose/volume of the prescription isodose) and homogeneity index (maximum dose in treatment volume/prescription dose) were calculated [15,16].

Figure 1 illustrates a typical dose distribution achieved. In this case the Radiation Therapy Oncology Group conformity index, gradient index and homogeneity index were 1.84, 2.55 and 1.46, respectively.

Results

Ninety-nine patients were identified. Two patients were lost to follow-up due to relocation. Ninety-seven patients with over 1 year of radiological and/or clinical follow-up data were analysed for local control and non-auditory toxicity. The median follow-up was 2.4 years (range 1–11.5 years).

Baseline characteristics are summarised in Table 1. Nine patients (9%) had diabetes mellitus and one (1%) had type 2 neurofibromatosis. This patient had undergone surgical resection of a contralateral vestibular schwannoma and received SRS to a previously untreated tumour. Nine patients (9%) had undergone previous resection. Most patients lacked serviceable hearing at the time of treatment and