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Original Article

Long-term outcome of Gamma Knife radiosurgery in patients with tiny intracanalicular vestibular schwannomas detected by three-dimensional fast imaging employing steady-state acquisition magnetic resonance

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ABSTRACT

Objective: To evaluate the effectiveness and long-term outcome of Gamma Knife radiosurgery (GKRS) for tiny vestibular schwannomas (VSs) detected by three-dimensional fast imaging employing steady-state acquisition magnetic resonance (3D-FIESTA MR).

Materials and methods: Between January and December 2004, 3D-FIESTA MR of the brain was performed in patients who had physical health examinations at the Buddhist Tzu Chi General Hospital (Hualien, Taiwan). Tiny intracanalicular VSs (defined as a tumor volume < 0.5 cm^2) was detected in 13 patients (8 women and 5 men). The mean age of the patients was 60 years (range, 45–84 years). Hearing function was graded using the Gardner–Robertson (GR) classification. Dose planning was performed on intra-operative stereotactic contrast-enhanced images using multiple 4-mm isocenters. The mean tumor volume was 0.098 cm^2 (range, 0.013–0.4 cm^2). The mean margin dose was 12.4 Gy (range, 11–14 Gy), and the isodose line was set at a mean of 53.8% (range, 50–70%).

Results: Twelve patients had GR Grade I or II hearing before GKRS, and GR I or II hearing was maintained in 11 patients. Facial and trigeminal nerve functions were preserved in all patients. The tumor control rate was 100% at a mean follow-up period of 9.8 ± 1.1 years (range, 76–126 months). One patient developed acute vertigo 1 day after GKRS, which subsided after short-term use of steroids and did not recur.

Conclusion: With the application of 3D-FIESTA, tiny VSs can be detected early. Because low-dose (12–14 Gy) GKRS is safe and effective for long-term control of the growth of tumors with acceptable preservation rate of hearing function, it may be worthwhile to use 3D-FIESTA to detect tiny VSs and treat the patients using GKRS.

1. Introduction

Vestibular schwannomas (VSs) represent approximately 10% of all primary brain tumors, with an estimated annual incidence of one case per 100,000 individuals [1,2]. A European report showed that the number of VSs diagnosed each year has increased threefold in recent decades from the era of radiography to the era of computed tomography and magnetic resonance imaging (MRI). Over the same period, the mean size of the tumor at the time of diagnosis has gradually decreased from 35 (extrameatal diameter) to 10 mm [3–5]. Similar changes in the incidence and size have been reported in other studies [4–6]. With the decrease in tumor size at diagnosis, there are fewer symptoms, and unilateral sensorineural hearing reduction may be the only symptom [6–8].

Conflicts of interest: none.

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Recently, with advances in current MRI techniques, such as three-dimensional fast imaging employing steady-state acquisition magnetic resonance (3D-FIESTA MR), the chances of finding asymptomatic patients with tiny VSs have improved. Using the 3D-FIESTA technique, the anatomic structures within the internal acoustic canal (IAC) can be clearly visualized without gadolinium enhancement [9]. Therefore, there has been an increase in incidental visualization of intracanalicular VSs without significant symptoms and signs (Fig. 1). This raises a question about whether these tumors in the acoustic canal should be treated.

Gamma Knife radiosurgery (GKRS) was first performed by Leksell in 1969 [10]. Over the years, with advanced dose-planning software, MRI-guided dose planning, and dose optimization, the evolution of radiosurgery has revolutionized the management of VSs [11]. During the last decade, radiosurgery has emerged as an effective alternative to surgical removal of small- and moderate-sized VSs. To date, the concepts of performing radiosurgery for VSs have focused on the control of tumor growth, preservation of hearing function, and prevention of other cranial neuropathy with the application of low-dose radiosurgery [12–21].

This article seeks to delineate the long-term outcome of GKRS for proactive treatment of tiny intracanalicular VSs detected by 3D-FIESTA MR.

2. Materials and methods

2.1. 3D-FIESTA MR study

Between January and December 2004, 3D-FIESTA MR studies were performed on patients who received physical health examinations. The 3D-FIESTA pulse sequence provides excellent high-resolution images of fluid-filled structures with very short acquisition times. The FIESTA technique employs ultrashort repetition times and echo times, with very fast scan times and outstanding image contrast. This bright fluid sequence uses steady-state contrast mechanisms to provide high signal-to-noise ratio images with a strong signal from fluid while effectively suppressing background tissue. With the application of 3D-FIESTA MR, those anatomic structures within the acoustic canal can be better delineated, and contrast medium is not needed at the primary survey. Because gadolinium-enhanced MRI remains the gold standard for the detection of VSs, contrast study could be reserved for those patients with tumors shown on 3D-FIESTA MR (Fig. 2).

Unilateral tiny VSs (defined as a tumor volume < 0.5 cm^2) were detected in 13 patients with this procedure. The clinical characteristics of these patients are listed in Table 1. The patient series consisted of eight women and five men. The median age of patients was 60 years (range, 45–84 years). Audiograms for hearing function tests on the lesion side were evaluated according to the Gardner–Robertson (GR) classification [22]. Twelve patients had serviceable hearing function on the lesion side ear before treatment (defined as GR Class I and II), and one patient had Class III hearing function. Eight patients experienced minor symptoms such as tinnitus, vertigo, headache, or a combination of these symptoms. One patient had a family history of neurofibromatosis (type II), and his unilateral VS was found in a family survey by 3D-FIESTA study. Neither trigeminal nor facial neuropathy could be detected before treatment in any of the 13 patients. The tumor volume varied from 0.013 to 0.4 cm^2.

2.2. Radiosurgery technique

The procedure began with rigid fixation of a Leksell stereotactic frame (Model C; Elekta Instruments, Stockholm, Sweden) to the patient's head. Local anesthesia was applied to the scalp (5% bupivacaine and 2% lidocaine). MR stereotactic images were acquired with a fiducial system attached to the stereotactic frame and transported through a fiber optic Ethernet cable to the GammaPlan (Elekta Instruments) computer, in which images were checked for distortion/accuracy. Planning was performed on 1- or 2-mm slice thickness axial MR images with coronal and sagittal reconstructions. After optimizing the plan, a maximum dose to the target was determined. Radiosurgery was performed with a 201-source, cobalt-60 Gamma Knife and the patients' heads and stereotactic frames were immobilized within the appropriate collimator helmet at a calculated target coordinate. The treatment was accomplished in a single session by positioning the head serially for each subsequent isocenter until a fully conformal field encompassed the tumor volume.

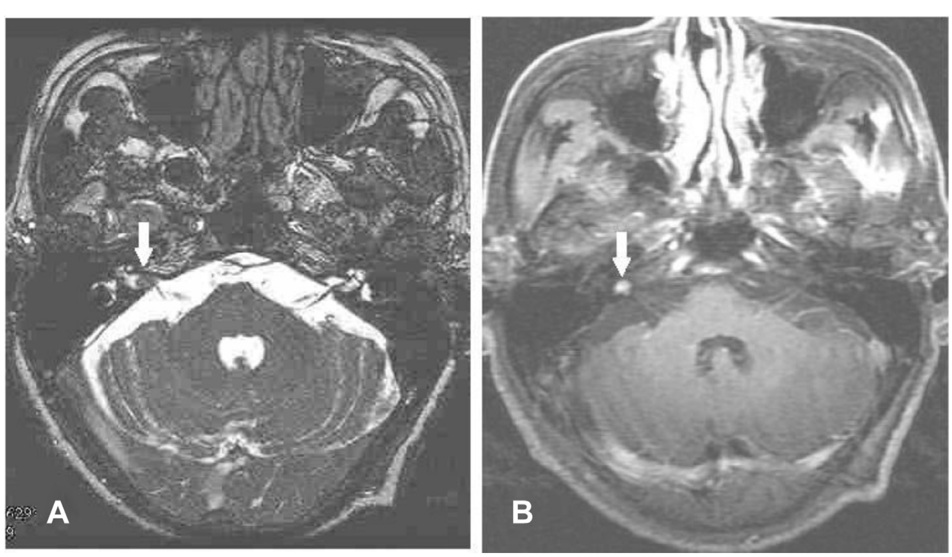

Fig. 1. (A) Three-dimensional fast imaging employing steady-state acquisition magnetic resonance shows an intracanalicular vestibular schwannoma (VS, white arrow) in the right internal acoustic canal. (B) Contrast magnetic resonance-enhanced study confirms the tiny VS (white arrow).