Gamma knife surgery for choroidal neovascularization in age-related macular degeneration

Technical note

MOTOHIRO HAYASHI, M.D., MIKHAIL CHERNOV, M.D., MASAO USUKURA, R.T., KAYOKO ABE, M.D., YUKO ONO, M.D., MASAHIRO IZAWA, M.D., SADAO HORI, M.D., TOMOKATSU HORI, M.D., AND KINTOMO TAKAKURA, M.D.

Departments of Neurosurgery, Neuroradiology, and Ophthalmology, Tokyo Women’s Medical University, Tokyo, Japan

The authors conducted a study to determine a way of overcoming the poor-quality demonstration of choroidal neovascularization (CNV) associated with age-related macular degeneration (AMD) on conventional magnetic resonance (MR) imaging studies.

The poor MR imaging demonstration of CNV in patients with AMD makes the use of gamma knife surgery more difficult. This difficulty, however, can be overcome by use of a modified time-of-flight MR imaging sequence with Gd enhancement and coronal reconstruction.

KEY WORDS • gamma knife surgery • age-related macular degeneration • treatment planning

A ge-related macular degeneration is the most common cause of blindness in people over the age of 65 years. Two forms of the disease can be differentiated—namely, atrophic or nonneovascular and exudative or neovascular. The latter is characterized by formation of the CNV beneath the retina, which is accompanied by a leakage of fluid, extravasation of blood, and formation of a fibrous scar. Classic CNV demonstrates more or less clear boundaries, whereas an occult form is poorly defined because of coverage by blood, lipids, and retinal pigment epithelium.

There is growing interest in GKS for treatment of patients with exudative AMD; however, poor delineation of the lesion on the conventional MR imaging sequences creates a significant problem. In our experience it was possible to achieve direct demonstration of CNV by using a modified Gd-enhanced TOF MR imaging sequence.

Report of Two Cases

Two patients with exudative AMD were treated by GKS at Tokyo Women’s Medical University (Leksell model C; Elekta Instruments AB, Stockholm, Sweden). One patient had both eyes affected; thus three lesions were treated.

On the day of treatment the Leksell stereotactic frame was placed after administration of a local anesthetic; we attempted to position the frame’s horizontal plane parallel to the optic pathways. Immobilization of the eye was achieved by transconjunctival fixation of the rectus muscles with sutures tied to the stereotactic frame.

For treatment planning and radiation dosimetry thin-slice (0.5-mm-interval) axial 3D heavily T2- and T1-weighted post-Gd MR imaging was performed for the two initially treated lesions; however, because CNV could not be well defined, a margin dose of 10 Gy at the 80% isodose was used. The treatment of the third lesion was based on the additional modified TOF sequence (TR 25 / TE 6.8 / FA 20 / ST 1.0 / NAQ 1.0) with Gd enhancement. The coronal reconstructed images of the modified TOF permitted direct demonstration of the CNV as shown in Fig. 1. This facil-
tated treatment planning, which was conducted using a margin dose of 15 Gy at the 60% isodose line as shown in Figs. 2 and 3. No complications or adverse effects have occurred. During the short-term follow-up period all three treated lesions exhibited good control.

Discussion
Prevalence of neovascular AMD in elderly populations varies from 0.57 to 1.52%, whereas disease-related visual impairment affects on average 3.5% of those who are 75 years of age or older.7 Loss of vision is influenced by its acuity at presentation and the size and composition of the CNV, but altogether two thirds of patients will become blind secondary to the disease over 2 years. The current treatment options are directed at the prevention, elimination, or modification of CNV by surgery, laser treatment, photodynamic therapy, chemotherapy, or radiotherapy.9 The effectiveness of the traditional management, however, is modest at best.1,3,4,8 Thus, there is an active search for new treatment modalities.

The key elements of CNV formation are vascular endothelial cell proliferation and angiogenesis. Although both of these can be inhibited by irradiation, doses close to 50 Gy are required. Such high doses can be associated with significant side effects if external-beam radiation therapy is used. Brachytherapy can reduce the complication, but it necessitates surgical incision. Therefore, there is growing interest in GKS because it can provide precise delivery of ionizing radiation to targets beneath the retina without damage to retinal structures. Haas, et al.,3 treated 11 patients with exudative AMD and classic CNV by using GKS with a prescription isodose of 10 Gy. In six of 10 patients who were followed regularly during a period of 12 months, visual acuity stabilized. Occult CNV, however, is difficult to treat by GKS because the lesion is poorly demonstrated on traditional MR images.

Time-of-flight is a well-known MR imaging sequence that is widely used for the demonstration of intracranial vessels and vascular disease. We have recently used a modified version of TOF.5 It permits direct demonstration of CNV in patients with exudative AMD, thereby creating new opportunities for radiosurgical treatment, particularly at higher doses.

Our experience with GKS for CNV in patients with AMD remains limited. Although disease stabilized in all
Fig. 2. Pretreatment 3D delineation of CNV by using the Leksell GammaPlan.

Fig. 3. Treatment plan for CNV in a patient with AMD.
Gamma knife surgery for macular degeneration

Address reprint requests to: Motohiro Hayashi, M.D., Department of Neurosurgery, Neurological Institute, Tokyo Women’s Medical University, 8-1 Kawada-cho, Shinjuku-ku, Tokyo, 162-8666, Japan. email: GKRmoto@aol.com.