LETTERS TO THE EDITOR

Gamma Knife surgery for trigeminal pain due to benign and malignant skull base tumors

TO THE EDITOR: We have read with great interest the recent article by Phan et al.,5 discussing the role of Gamma Knife surgery (GKS) for trigeminal neuralgia (TN) secondary to recurrent malignant skull base tumors (Phan J, Pollard C III, Brown PD, et al: Stereotactic radiosurgery for trigeminal pain secondary to recurrent malignant skull base tumors. J Neurosurg [epub ahead of print April 27, 2018. DOI: 10.3171/2017.11.JNS172084]). The authors nicely discuss tumor control, symptom palliation, and opioid use/dependency.

The authors’ study highlights several important aspects. First, it underlines the role of single-fraction GKS as a primary treatment option for recurrent malignant skull base tumors in the context of secondary TN. Furthermore, in selected cases, the Extend system (Elekta AB) was used for hypofractionation. The potential role of the new Gamma Knife model ICON (Elekta) should also be underscored for this indication, because it allows frameless stereotactic treatment using a combination of cone-beam CT (CBCT), a thermoplastic mask system (allowing replacement in well-selected cases of the Leksell stereotactic G frame), and an infrared-based high-definition motion management camera system for patient tracking during treatment delivery.8 In fact, the ICON nicely combines the flexibility of the mask and CBCT with the well-known remarkable dose distribution and steep dose fall-off of the GKS treatment.8 Second, there is a need for tumor targeting and oncological control as a primary outcome. In cases of TNs related to benign skull base tumors, a wide variety of technical nuances have been reported, including initial targeting of the tumor only,7 targeting of

FIG. 1. Targeting of a metastasis of the Meckel’s cave from a pulmonary carcinoma (upper left), of a meningioma of the petrous apex (upper center), of a trigeminal schwannoma (upper right), and of an arteriovenous malformation (lower left and right) (all cases were symptomatic with a TN, which further resolved after GKS treatment). Figure is available in color online only.
the tumor and the nerve during the same session, and targeting of tumor and nerve at different time points. This makes the analysis of the outcomes, in terms of safety and efficacy, more difficult. Third, there is a radiobiological rationale that explains a more rapid decrease in lesion size compared with that of benign tumors, which would also explain, in some instances, the quick relief with regard to the nerve compression and further symptom alleviation. It is now well established that malignant tumors have higher $\alpha/\beta$ ratios, estimated to be closer to 10 and representative of early-responding tissues, whereas slow-growing benign brain tumors such as pituitary adenomas, arteriovenous malformations, and benign meningiomas have lower $\alpha/\beta$ ratios, estimated to be closer to 3 and representative of late-responding tissues.

In conclusion, the report by Phan et al. underlines the potential role of GKS in new indications, including skull base malignancies in patients with trigeminal pain, as in the context of a combined management for residual tumors after surgery and/or in cases of recurrence (Fig. 1). It also highlights the fact that GKS remains “an optimal skull base” tool due to its steep gradient, allowing optimal tumor coverage while sparing and/or improving neurological function. Furthermore, in benign, tumor-related secondary TN, the current literature is heterogeneous and does not answer to three essential questions: when (at what exact time point), what (is it the tumor? is it the nerve? both?), and how to target (retrogerasserian versus root entry zone, etc.). On the other hand, in malignant skull base tumors, local control is the primary aim, and so there is limited room for technical nuances.

Constantin Tuleasca, MD1,3
David Patin4
Marc Levivier, MD, PhD, IFANS1,2
1Lausanne University Hospital (CHUV), Department of Clinical Neurosciences, Neurosurgery Service and Gamma Knife Center, Lausanne, Switzerland
2University of Lausanne (Unil), Faculty of Biology and Medicine (FBM), Lausanne, Switzerland
3Ecole Polytechnique Fédérale de Lausanne (EPFL), Signal Processing Laboratory (LTSS), Lausanne, Switzerland
4Institute of Radiation Physics, Lausanne, Switzerland

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Lausanne University Hospital.

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Disclosures
The authors report no conflicts of interest.

Correspondence
Constantin Tuleasca: constantin.tuleasca@gmail.com.

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Response
We thank Dr. Tuleasca and coauthors for their kind comments and interest in our study. This manuscript was written shortly after FDA clearance of the Gamma Knife ICON model (Elekta AB), and therefore the patients included in this study were largely treated with frame-based, single-fraction Gamma Knife surgery (GKS), with 4 cases treated with fractionated GKS using the Extend immobilization system. As the authors from Lausanne have nicely summarized, the Gamma Knife ICON has a mask-based immobilization system, an infrared-based high-definition motion management system to track intrafraction motion, and cone beam CT image guidance. This system has the potential to deliver frameless single- and multifraction GKS and can be considered for use in the treatment of malignant skull base tumors causing trigeminal pain, as described in this article. We agree the patients in this study treated with Gamma Knife Extend (end-to-end accuracy < 2 mm)3,5 are also appropriate candidates for treatment with the ICON system. A potential advantage of the ICON system is increased tolerability and comfort with a frameless mask system. In our experience, the Extend system requires candidates to have calm demeanors, good dentition due to a vacuum-assisted bite block with custom prosthesis, and to be absolute non-gaggers.

As Tuleasca et al. appropriately alluded to, our goal and intent for each case is to treat the entire tumor to establish oncological control. There were a few exceptions when the entire tumor was not treated because the area in question was near a critical structure and not conclusively identified as tumor on imaging. However, in retrospect, these areas likely harbored tumor and subsequently progressed on MRI. This supports a major theme in this study that it is necessary to completely cover the tumor, and a frank discussion with the patient should take place regarding the potential toxicity risks associated with reirradiation. We believe one of the significant findings in this study is that among those with radiographic evidence of tumor control after GKS, there is a significant palliative impact that is