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Editorial

Using a Robotic Stereotactic Radiation Treatment System to Treat Benign Intracranial Tumors and Trigeminal Neuralgia

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Background

The recent advance of stereotactic radiation treatment systems [1-3] has allowed patient with benign intracranial tumors and trigeminal neuralgia to be treated with stereotactic radiosurgery (SRS). Frameless stereotactic treatment is less invasive than the traditional Gamma Knife [3,4]. The frameless stereotactic machines may also be used for image guidance to deliver precise radiation doses in hypofractionation or conventional fractionations when the tumors are large or close to critical structures such as the chiasm [1,4]. Hypofractionated stereotactic treatment may be advantageous for these benign conditions. The oxygenation of these tissues, unlike malignant tumors, is not hypoxic. Thus fewer fractionations may not compromise the re-oxygenation [4]. The α/β ratio for benign tumors and trigeminal nerve is presumed to be that of the normal late responding tissues. For example, stereotactic body radiation therapy (SBRT) using CyberKnife has been found to be effective in treating prostate cancers because of their low α/β ratio of about 1.5 [5]. This paper is a part of a series discussing the utility of modern stereotactic radiation treatment systems in challenging clinical scenarios [6].

Treatment Planning and Stereotactic Radiosurgery

The stereotaxy of modern SRS machines may improve the outcomes and limit the toxicities when treating skull base structures. For example, CyberKnife robotic stereotactic radiation system [7] uses skull tracking, and with the many degrees of freedom of the robotic arm, it could deliver very high dose efficiently and safely with near real time tracking. Other advanced systems may have similar capacities [8-10]. Magnetic resonance imaging (MRI) may be useful in treatment planning for treating acoustic neuroma, pituitary adenoma and trigeminal neuralgia. For example, the CyberKnife treatment planning computer system allows multi-modal image registration including computed tomography (CT) to MRI image registration. This would allow more accurate target delineation in these cases.

Acoustic Neuroma

Acoustic neuroma (vestibular schwannoma) is a benign tumor of the vestibular branch of the vestibulocochlear nerve responsible for hearing and equilibrium [1]. The tumor usually occurs at the internal auditory canal of the temporal bone at the base of skull at the cerebellopontine angle. Even small tumors at this location could cause hearing and equilibrium problems, and they may eventually also compress the brainstem and cranial nerves [1]. Observation, micro-surgery and SRS are the main treatment options [1,3]. The Gamma Knife dose given in this case is about 12 Gy in a single fraction [11,12]. Recently, more frameless radiosurgery systems have been used because of their non-invasive nature and the treatment could be fractionated [1,2]. For example, the typical dose for CyberKnife is 21 Gy – 25 Gy in 3-5 fractions prescribed to about 80 % [1,2]. Fast Imaging Employing Steady State Acquisition (FIESTA) MRI may be useful for treatment planning in this scenario [1]. With SRS or fractionated SRS, the tumor control is more than 90%, crude hearing preservation is about 80%. Vestibulocochlear nerve and cranial nerves V and VII toxicities are typically less than 20% and are usually not severe with modern fractionated SRS [1,2]. For these reasons, modern SRS and fractionated SRS treatments are gaining popularity over the last two decades [13].

Pituitary Adenoma

Pituitary adenoma is a benign intracranial tumor occurs mostly between 20 to 50 years of age. It could be functioning or non-functioning [14]. Treatment goal for the functioning pituitary adenoma is to control the hormonal secretion of the anterior pituitary lobe. The treatment goal for non-functioning pituitary adenoma is to control the tumor to avoid compressing on the visual chiasm and optic nerves, or causing significant endocrinopathies [14]. Pituitary tumors causing visual problems are usually treated with transsphenoidal surgery or craniotomy [14,15]. Observation may be appropriate for asymptomatic patients. Radiation therapy is considered if the tumor invades into the cavernous sinuses or there is residual or recurrent disease [14,16]. Stereotactic radiation treatment systems could avoid critical structures including the optic nerves and chiasm [4,14-16]. The dose given by Gamma Knife is generally about 14 - 20 Gy in one fraction [16]. Recently, more frameless radiosurgery systems [14] have been used in treating pituitary adenoma and the treatment could be fractionated. The typical dose used for CyberKnife for example about 21 Gy – 25 Gy extended over 3-5 fractions prescribed to about 80 % [14]. Because for its precision, the planning target volume (PTV) margin could be as small as 0-2 mm [14,17]. The tumor control rate is high (more than 90% in most studies) and the toxicity is low with modern SRS and fractionated STS treatments [16]. These toxicities may include uncommon visual complications and about 30% risk of

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hypopituitarism [16]. To reduce side effects, fractionated SRS may be more preferable than the single fraction SRS [14].

Trigeminal Neuralgia

Trigeminal neuralgia is a chronic pain condition of the 5th cranial nerve that runs to the Merkel's cave of the temporal bone. Drug therapy and surgical microvascular decompression are the main treatments for trigeminal neuralgia [3]. Second line treatments include ablative treatments such as glycerol rhizotomy, balloon compression, and radiotherapy [3]. SRS with Gamma Knife has been used to treat [18] and re-treat trigeminal neuralgia [19]. 4mm of the cisternal trigeminal nerve segment is treated to 40 Gy (about 75 Gy maximal dose) [20] - 45 Gy (about 80 – 90 Gy maximal dose) [21]. For fractionated SRS, the typical dose used for CyberKnife for example is 60 Gy treating 6mm of cisternal segment of the trigeminal nerve prescribed to about 80 % isodose line [21]. Maximum pain relief is usually achieved within one month, but about 15 % of treated patients would not achieve 50 % of pain relief. Median time to pain recurrence is less than 12 months [22]. About 15 % treated patients would have facial numbness. Transient hearing loss, facial palsy and loss of taste could also occur [22]. Furthermore, CyberKnife fractionated SRS has been suggested to be more cost effective when compared to surgery [3].

Conclusion

SRS and fractionated SRS are safe and effective in treating benign acoustic neuroma, pituitary adenoma and trigeminal neuralgia. They should be considered among the treatment options.

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