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Interstitial brachytherapy with iodine-125 seeds for low grade brain stem gliomas in adults: Diagnostic and therapeutic intervention in a one-step procedure

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ABSTRACT

Purpose: To report on iodine-125 (I125) interstitial irradiation in the treatment of low grade brain stem gliomas in adults.
Patients and methods: Ten patients with well-circumscribed lesions of the brainstem and histological confirmation of low grade glioma treated with stereotactically implanted I-125 seed in our department between 1995 and 2012 were retrospectively analyzed.
Results: In 9 patients the lesion was treated with one I-125 seed and in one patient, 2 spatial separated lesions were implanted, therefore a total of 11 I-125 seeds were implanted. The mean volume of the 11 lesions was 2.76 ml (range: 0.5–7.2 ml), mean activity of the seeds was 6.23 mCi (range: 1.5–11.1 mCi), mean duration of irradiation was 28.5 days (range: 21–41 days) and mean effective dose rate was 9.16 cGy/h (range: 6.2–12 cGy/h). The 30 days perioperative morbidity and mortality rate was 0%. Median follow up was 72.5 month (range 5–168 months). Six of ten patients were free of progression until last follow up.
Conclusion: In our experience at the University Clinic in Freiburg Germany, interstitial radiosurgery based on MRI is a safe and effective method to diagnose and treat low grade gliomas of the brain stem. Furthermore randomized studies are needed to confirm the therapeutic impact of this method in comparison to external beam radiation of brain stem gliomas.

1. Introduction

Brainstem glioma in adults is a rare and poorly characterized disease. Therapeutic alternatives are mainly limited to external beam radiation as surgery is only indicated for exophytic tectal gliomas and the role of chemotherapy is still undefined. However several reports in the literature underlined the necessity to confirm histopathologically the presence of a brain stem glioma due to diagnostic inaccuracy of preoperative magnetic resonance imaging (MRI). Therefore we suggest the management of patients with brain stem glioma by stereotactic biopsy and implantation of I125 seeds for interstitial radiosurgery in a single step procedure as an alternative to external radiation therapy.

2. Patients and methods

2.1. Study population and follow up examination

We reviewed 10 patients with well-circumscribed lesions of the brainstem and with histological confirmation of low grade glioma treated with stereotactically implanted I-125 seeds (half-life of 60.2 days, photon energy spectrum ranging between 27 and 35 keV) in our department between 1995 and 2012. Patients were examined neurologically before, and then 3 and 6 months after surgery were followed by twice annually up to 14 years after surgery (range 5–168 months, mean 72.1 months). The follow up review comprised examination of patient records, pathology reports, surgical records, radiation therapy reports, MRI, and either a personal examination or contact with the patients, their families, or their physicians.

The Karnofsky Performance Scale (KPS) was used to evaluate the quality of life and the Kaplan–Meier analysis was employed to determine life expectancy.

There were 7 males and 3 females, with an average age at diagnosis of 39.4 years (range 28–60 years) with a peak in the

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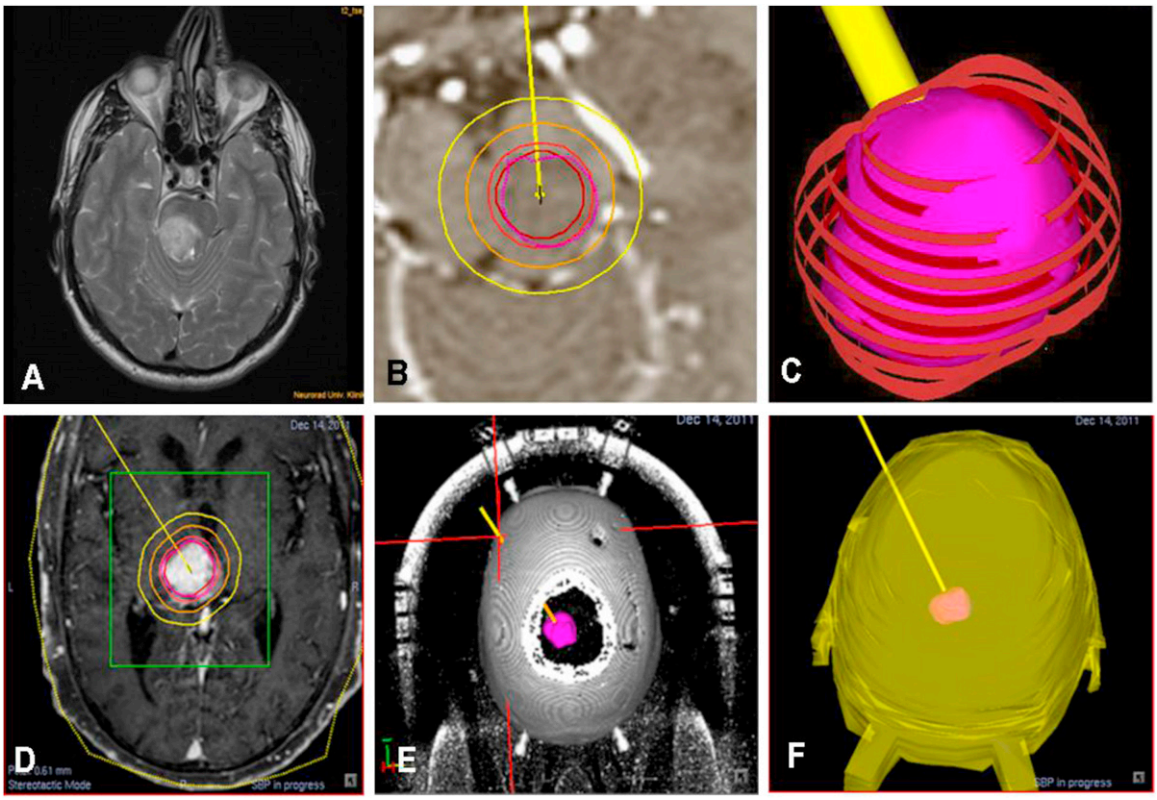

Fig. 1. Planning of 2 different patients for SEED I125 implantation. On the upper part of the figure: (A) MRI T2-wAxial image showing a circumscribed mesencephalic lesion. Histology reported an anaplastic astrocytoma (WHO II). (B) Planning of dose distribution. (C) 3-Dimensional isodose distribution. On the bottom: patient with astrocytoma (WHO II). (D) MRI T1-waxial view of isodose distribution on circumscribed lesion, located on the upper part of the left mesencephalon and thalamus. (E) 3-Dimensional analysis of the presurgical planning showing the stereotactic frame, the entry point of the catheter and the target with the tumor. (F) 3-Dimensional reconstruction showing idodose distribution and catheter containing the I125 seed.

third and fourth decade. Initial MRI evaluation with T1 weighted sequences after gadolinium and T2 weighted sequences showed a lesion with involvement of the brain stem in all cases. In addition 6 out of 10 cases had contrast enhancement. Localization of the lesions was: 7 in the midbrain (2 with compromise of the pedunculus cerebelli), 2 in the pons and 1 in the medulla oblongata.

2.2. Stereotactic biopsy and I-125 seed implantation

The Riechert/Mundinger stereotactic device was used for the stereotactic biopsy and interstitial implantation of the I125 seeds. Accurate definition of the target volume, and of adjacent radiosensitive structures, was performed using image fusion of preimplant high-resolution magnetic resonance imaging with T1 three-dimensional data sets after gadolinium application and T2 weighted sequence (1 mm slices, unreformatted) and intraoperatively acquired CCT scans (2 mm, transversal view, postcontrast, Siemens Somatom Plus, see Fig. 1).

Stereotactic biopsy was performed via a 6-mm burr hole under local anesthesia and continuous cardio-vascular monitoring. After intraoperative histological confirmation of a glioma, implanation of I-125 seeds was performed in the same session. A temporary seed containing the radiation source (I-125) sealed within a Teflon catheter was introduced stereotactically into the target under continuous radiological assessment with an intraoperative biplanar x-ray unit. Correct placement was confirmed immediately postoperative by a stereotactic CCT and fusion with the treatment plan.

Table 1
Summary of therapeutic procedure. L: localization, Mid: midbrain, Med: medulla; NoS: number I-125 seeds; TR: tumor radio; TV: tumor volume; EDR* energy dose rate; OS: overall survival; m = months; F-up: follow up; D: death; SD: standard deviation.

Patient	L	Histopathology	NoS	TR	Activity	TV	EDR*	Days of treatment	F-up	D
1	Mid	Pilocytic Astrocytoma GI	1	12 mm	10.9 mCi	7.2 ml	7.8 cGy/h	32	168 m	
2	Med	Ependymoma GII	1	9 mm	7.2 mCi	3.1 ml	10.3 cGy/h	24	148 m	
3	Mid	Low gradeAstrocytoma	1	10 mm	10.3 mCi	4.2 ml	12 cGy/h	21	71 m	X
4	Mid	Pilocyticastrocytoma GI	1	9 mm	6.4 mCi	3.1 ml	9.1 Cgy/h	28	154 m	
5	Mid	Pilocyticastrozytoma GI	1	5 mm	1.5 mCi	0.5 ml	6.2 cGy/h	41	70 m	
6	Mid	Astrocytoma GII	2	12 mm	5.1 mCi total	Overall 4 ml (2 ml each)	10 cGy/h	25	62 m	X
7	P	Astrocytoma GII	1	9.3 mm	9.2 mCi	3.4 ml	11.4 cgy/h	22	34 m	X
8	P	Pilocyticastrocytoma GI	1	7.5 mm	3.49 mCi	1.8 ml	6.94 cGy/h	36	5 m	X
9	Mid	Pilocyticastrocytoma GI	1	6.7 mm	3.29 mCi	1.3 ml	8.93 cGy/h	28	7 m	
10	Mid	Pilocyticastrocytoma GI	1	7.55 mm	5.01 mCi	1.8 ml	8.93 cGy/h	28	6 m	
Mean	–	–	1.1	8.8	6.23	2.76	9.16	28.5	72.5	–
SD	–	–	0.31	2.21	3.15	1.80	1.84	6.29	63.5	–