Stereotactic Radiosurgery for Recurrent Glioblastoma Multiforme using Yeungnam Localization Device

-- Technical note and Clinical trial --

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Authors performed a stereotactic radiosurgery with multiple noncoplanar convergent photon beams of linear accelerator (NELAC-1018 18 MeV, NEC) using a specially designed Yeungnam localization device for two patients with recurrent glioblastoma multiforme.

One patient had 2 cm sized and the other 4 cm sized mass on the CT images. After single session of treatment with 15 and 20 Gy, headache was improved in a few days after radiosurgery with no remarkable untoward reactions. Our experience with these two patients were encouraging and we found that our localization device, which is easily adjustable and inexpensive, could be a valuable tool for stereotactic radiosurgery particularly in the treatment of recurrent brain tumor.

Key Words: Recurrent brain tumor, Stereotactic radiosurgery, Yeungnam localization device, Linear accelerator

INTRODUCTION

Glioblastoma multiforme is highly malignant neoplasm representing 15~20% of all intracranial tumors and 50% of all glioma[1]. After surgical removal and postoperative irradiation, malignant gliomas recur locally in most cases[2].

There has been a considerable interest in interstitial brachytherapy for the treatment of brain tumors[3~5], reported results were unsatisfactory. Recently stereotactic radiosurgery using gamma knife[6] or linear accelerator[7] were utilized for the treatment of brain tumor and various treatment results were reported.

Authors report 2 cases with recurrent glioblastoma multiforme which was treated with radiosurgery using a specially designed Yeungnam localization device on 10 MV linear accelerator with multiple noncoplanar convergent beams and we describe an easily adjustable inexpensive localization device.

MATERIALS AND METHODS

1. Basic Concept

This technique is essentially based on the composition of multiple isocentric arc irradiations with small beams centered in the stereotactic target to reach a high dose.

A single arc is performed during the rotation of the radiation source around the target. Arcs are repeated while the patient is set in various couch angles around a vertical axis passing through the stereotactic target.

2. Linac Preparation

The treatment machine is a standard linear accelerator (NELAC-1018, NEC Co.). Since the technique involves placing the target accurately on the isocenter of the system, and then irradiating it with multiple non-coplanar rotations of the gantry, it is important to be sure that the axes of rotation of the gantry, treatment couch and collimator all intersect at or very close to a common point and remain stable during rotation. Mechanical and physical accuracy of our machine has been presented previously[8]. In order to decrease the penumbra of the beam, a new collimation block was built (Fig. 1).

3. Stereotactic Localization Device

Authors designed a new model of localization device made of transparent acrylic plates (Fig. 2). This device is a rectangular box like structure and consisted of one basal plate, 2 lateral panels, 1 frontal panel and 1 vertex panel. The size of the device is 35×35×35 cm and the basal plate is 35 cm wide and 50 cm long.

The weight of the device is 5.0 kilograms. The specifications of individual components of the device are as follows: The basal plate is made of 1

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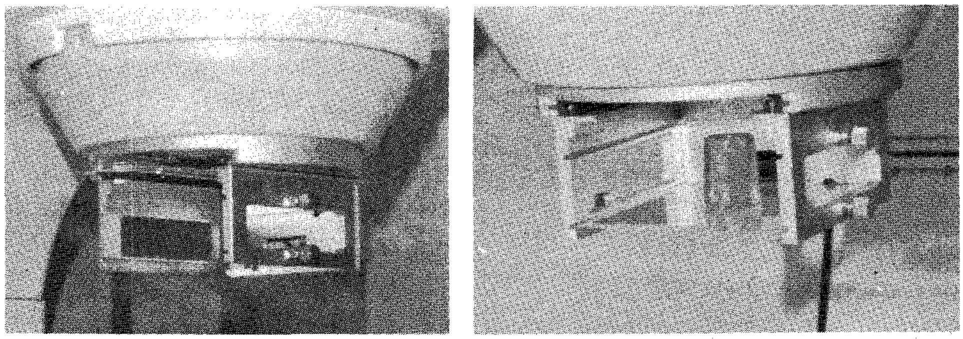

Fig. 1. Left. A standard block tray. Right. A supplemental collimator.

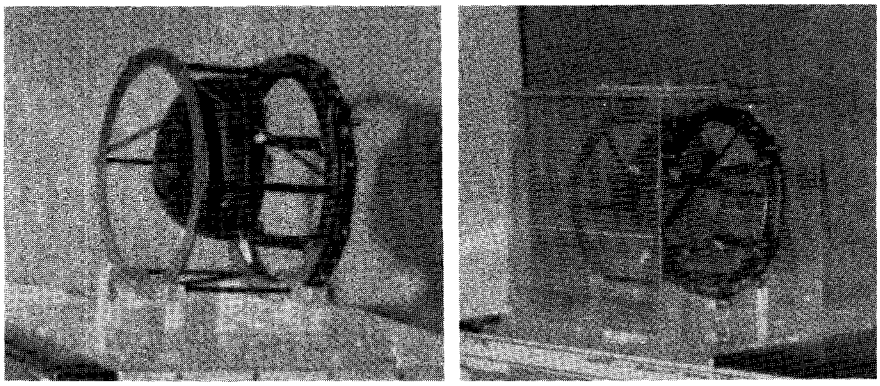

Fig. 2. Left. Cranial portion of phantom with BRW stereotactic frame on basal plate of Yeungnam localization device. Right. full set of the Yeungnam localizaiton device. Note radioopque side bars and millimeter scales on side panels.

cm thick acrylic plate and has a set of support for base ring of BRW stereotactic system.

This supporting system is reinforced by screw binder.

The frontal and two lateral panels are made of 0. 5 cm thick and have a series of holes for localization at a distance of 10 mm from each other and are supplied with millimeter scales along both sides of the panels to facilitate an exact repositioning of the device. A set of radiopaque bars, 3 mm thick, is placed along midline of each panels as the reference structures for localization CT scanning (Fig. 3).

The radiopaque bar on the frontal panel is to be reference point for the laterality coordinate, x; the radiopaque bars on the lateral panels are to be the reference point for the anteroposterior coordinate, y; and the cranial surface of the base ring of BRW frame is to be the reference point for the height coordinate. z.

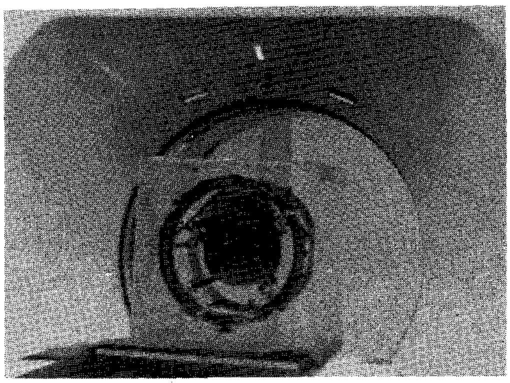

Fig. 3. Planning CT with Yeungnam localization device

These reference structures have to be parallel to the transverse light beam of CT gantry and horizontal laser beam of treatment suite.

4. CT Guided Target Localization with Yeungam Localization Device

We use CT scan to localize the target with Yeungnam localization device. The CT scan is used mainly to obtain anatomical and geometrical data for dosimetry.

The BRW base ring is attached to the patient's head in the usual manner. The patient within the localization device is immobilized on CT couch in such a way that the radiopaque bars of the lateral panels are parallel to the transverse light beam of the CT gantry and the axial plane along the cranial surface of BRW base ring aligned with the sagittal light beam (Fig. 3).

Serial parallel scanning is then done with 2 mm thick slices in 2 mm steps through the tumor area and the diameters of the tumor in the three planes are measured and the tumor center is assessed.

The coordinates, x, y, and z, of the tumor center are measured by CT unit in relation to the reference points on the panels of the device and the isocenter is marked on the side panels of the device using transverse light beam of CT gantry.

These marking procedures of isocenter is repeated on the patient's skin after detachment of side panels permitting double checking system for the least localization error.

5. Treatment Planning

Therapeutic information obtained from CT scanning; the size and distances of the lesion from predetermined reference points of the localization device, and the beam characteristics are used in determining the size, number, and location of treatment arcs and radiation dose for each arc. The target volume received an absorbed dose of 90% of the dose at the isocenter.

6. Operating the Radiosurgery System

After preparation of the therapy suite, which including attaching the collimator to the gantry, securing the basal plate of the device to the treatment couch, the patient with BRW base ring is moved onto the treatment couch.

The target center is made to coincide with the isocenter of the linear accelerator which is marked on the side panels of the device, and laser beam of the treamtent suite (Fig. 4). Accurate localization was scrutinized and verificaiton was taken at vertical direction.

The actual treatment after removal of localization device consists of radiating the lesion during a series of arc rotations of the gantry, each with the couch in a different position.

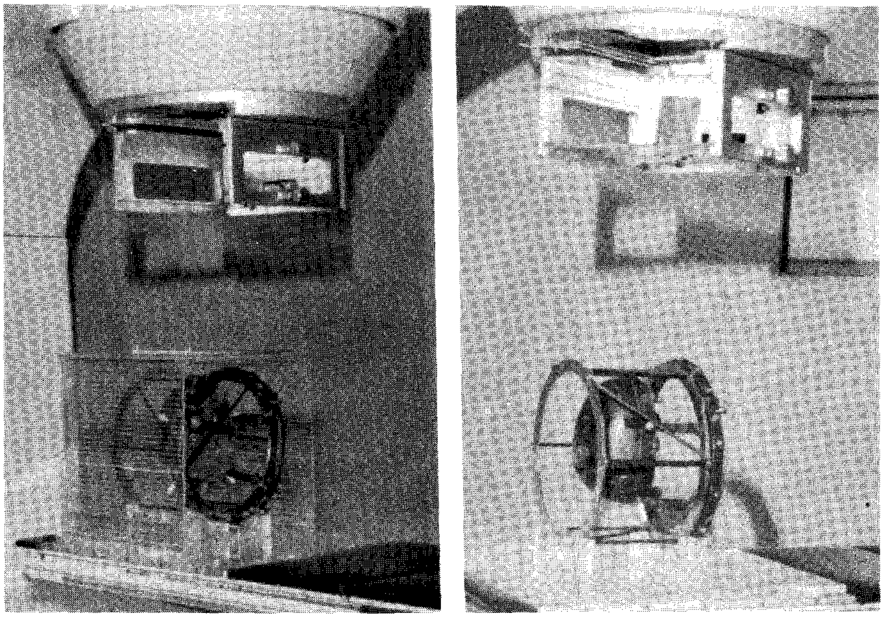

Fig. 4. Left. Isocenter localization using laser beam of treatment suite. Right. Picture of actual radiosurgery.

7. Clinical Trial and Results

The positional accuracy of both target localization and irradiation was investigated using the cephalic portion of Alderson Rando phantom Obtained results were presented previously[8].

The distance between the isocenter and the target is less than 3 mm during rotation of the assembly and this accuracy has been accepted satisfactory in clinical practice. A 47 year old and a 34 year old female patients were selected for the treatment of radiosurgery.

They were relatively well being after previous resection and postoperative radiotherapy, recently headache and neurological impairment were noted. Cranial CT showed recurrent mass densities about 2 cm and 4 cm, respectively.

They were irradiated 1500 and 2000 cGy, during and after the radiosurgery procedures the patients were well tolerated and headache was improved without noticeable treatment related untoward reactions. Clinical data of these two patients were summarized in table 1.

DISCUSSION

In 1951, Leksell introduced radiosurgery in the treatment of intracranial target[6]. There are various radiosurgery techniques with photons[7], proton Bragg-peak irradiation[9] and Co-60 gamma knife[6,10]. Stereotactic radiosurgery with the "gamma knife" is extremely precise, but requires an expensive, and dedicated equipment[11].

On the other hand, stereotactic radiosurgery using a linear accelerator gives an equivalent treatment and could be carried out whenever an isocentric linear accelerator is available[11~13].

But exact target localization is most important for radiosurgery and there are various commercially available localization systems which are very expensive.

Authors fabricated a localization device with 0.5 cm thick acryl plate. Our localization system is simple, inexpensive bur permits to apply for any available linear accelerator.

The most important physical characteristic of a system for stereotactic radiosurgery is the positional accuracy with which it can deliver radiation[14].

Our localization system was simulated with phantom and verified with film dosimetry before clinical application and it's geometric error was within 3 mm. Development of this technique requires meticulous measurement of system alignment and of the dosimetric properties of small sized beams, as well as a judicious choice of treatment dose and selection of patient.

In summary, we have developed a specially designed localization device which is a relatively simple and inexpensive but permits an acceptable geographic accuracy and easy adjustment with CT scanner and linear accelerator.

Our experience with 2 cases with recurrent glioblastoma multiforme are encouraging without treatment related side effects. Linear accelerator based radiosurgery with our device could be an effective and relatively safe palliative tool in the management of recurrent brain tumors.

Table 1. Patient Characteristics

	case 1	case 2
age (years)	47	34
sex	female	female
interval from diagnosis	8 months	12 months
previous surgery	total removal	partial removal
previous radiotherapy	6500 cGy	6500 cGy
original location	left frontoparietal	left parietal
recurrent location	left parietal white matter	left parietal grey and white matter
lesion size (diameter)	2 cm	4 cm
field size	2×2 cm	3×3 cm
radiosurgery (cGy)	1500	2000
No. of arcs	6	4
sum of angle	670°	530°
acute side reaction	none	none
treatment result	improved	improved

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국문초록 =

뇌정위적 방사선 절제술에 필요한 위치선정용기구 제작과 치험 2예

영남대학교 의과대학 치료방사선과학교실, 신경외과학교실*

신세원 · 김성규 · 김명세 · 김오룡* · 조수호*

재발성 두개강내 악성종양의 치료는 관습적으로 재수술이나 고식적 항암요법이 주된 치료법으로 이용되어 왔으나 치료효과는 만족스럽지 못하였다. 일부분의 치료기관에서는 뇌정위적으로 근접치료를 시도하였으나 선량분포의 불균일성과 시술상의 어려움으로 널리 사용되지 못하였다.

최근 방사선 영상진단기술의 발달과 치료기술의 발달에 힘입어 뇌정위적 방사선 절제술이 도입되어 그 이용범위가 넓어지면서 기능적 뇌절제술을 비롯하여 뇌동정맥기형의 치료나 뇌종양의 치료에도 많이 이용되고 있으며 고무적인 보고가 많다.

영남대학교 의과대학 치료방사선과학교실에서는 신경외과학교실과 합동으로 뇌정위적 방사선 뇌절제술에 필수적인 위치선정용 특수기구를 자체제작하여 전산화 단층촬영장치와 치료용 선형가속기에 적용가능성 여부를 검토한 후 인형 인체 모형과 필름을 이용하여 기계적 정확성과 방사선 선량 분포의 안정성을 확인한 후 과거에 근치적 뇌부분 절제술과 수술후 방사선치료를 시행후 재발된 두명의 악성 성상 세포종 환자에서 자체제작한 기구를 이용하여 뇌정위적 방사선절제술을 시행하여 고식적 치료에 합당한 증상개선의 만족스런 결과를 얻었으므로 위치선정용 기구의 특성과 치료성적을 문헌고찰과 함께 보고한다.