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Effect the Radiation Ionization on Workers in Gamma Knife

Yousif Jasim Abdali
Department of Medical Physics, Madenat al-Elem University College

Waleed Balbos Kudair
Department of Biology, College of Science, Al-Muthanna University

Rusul Mohammed Hasan
Department of Pathological Analysis, College of Science, Samarra University

Raad Hamza Hadi
Department of Dairy Technology, College of Food Sciences, Al Qasim Green Univer sity

Ahlam Mousa Shlaga
Department of Chemistry, College of Science, University of Karbala

Abstract:

The trigeminal nerve (the fifth cranial nerve) is the largest one between the cranial nerves and contains both sensory and motor fibers. The sensory fibers contain the General Somatic Afferent (GSA), and its function is general sensation. The motor fibers contain Special Visceral Efferent (SVE), its function is branchial arch striated muscles. To assess the efficiency of gamma knife treatment outcome of Iraqi patients who are suffering from primary TN (Trigeminal Nerve) and irradiated with a dose of 80 Gy and/or 89 Gy (recommended by gamma knife society with a dose range of 80-125 Gy), and to evaluate the change in nerve thickness. Gamma rays are considered to be the most dangerous radiation in the electromagnetic field, since they possess the highest energy because of their high frequency. As for their uses, they are used in the medical and industrial fields, but in very small quantities. The doses of radiation given to the patient are calculated so accurately

that they destroy the cancer cells. The healthy body cells regain their health after recovery and can follow the course of the body's vital processes. Also here in the project we have worked on measurements of the effect of radiation on the workers in this area where there is no effect on the workers outside the room when the device is operating and give radiation to the patient because the room is completely isolated from the arrival of any radioactive effects harmful to workers.

Keywords: *radiation. workers, gamma knife, fifth crnial nerve*

Introduction

The trigeminal nerve (the fifth cranial nerve) is the largest one between the cranial nerves and contains both sensory and motor fibers. The sensory fibers contain the General Somatic Afferent (GSA), and its function is general sensation. The motor fibers contain Special Visceral Efferent (SVE), its function is branchial arch striated muscles . [1]

Cranial nerve V exits the lateral aspect of the pons and courses anteriorly to synapse in Meckel's cave. The ganglion in Meckel's cave is known as the *gasserian* or *semilunar ganglion*. From the gasserian ganglion, cranial nerve V trifurcates. The sensory root passes to the trigeminal ganglion, from which emerge the ophthalmic (V1), maxillary (V2), and mandibular (V3) divisions. The three divisions of the trigeminal (V) nerve will be sensory to the skin of the face and scalp, to the mucous membranes of the oronasal cavity, and to the teeth. A motor root joins the mandibular division and will supply the muscles of mastication (chewing). Table (1.1) explains the components, function and their view from skull opining . [1] The trigeminal nerve is the second most commonly affected cranial nerve after the vestibular nerve and the most commonly affected nerve in the central skull base [3]. It can arise anywhere along the nerve, from its cisternal segment to the main extracranial branches [4]. Trigeminal Neuralgia is also called "Tic Dolourex" which is a French name for patient tendency to jump at the time that pain attacks [5]. TN is so important condition appears in the middle ages people or older, it characterized by intense (not tolerable) paroxysmal episodic pain 50% of the time at least. "It is of unknown cause and involves the pain fibers of the trigeminal nerve appears in: one or more divisions area of the trigeminal nerve (commonly occurring in 2nd and/or 3rd division)" [6]. describe this condition as a "suicide disease'' because of pain severity. The old age patients (more than 60 years old usually) are able to locate the affected pain division(s) more accurately .[7] Pain attacks the patient's as triggers by sensory stimuli every day, e.g. chewing, shaving, draughts of wind, drinking, applying make-up (female), and brushing teeth.[8] The word "stereotaxis" is derived from two Greek words: stereos, which means "three-dimensional", and taxis, which means "orderly arrangement". Radiosurgery is a neurosurgical procedure whereby radiation is delivered using stereotactic. It's called surgery because the treatment done in one session like surgery. In 1889, the first primitive stereotactic unit was used in Russia .[9] Radiosurgery according to Leksell 's definition says that "Stereotactic radiosurgery is a technique for the non-invasive destruction of intracranial tissues or lesions that may inaccessible to or unsuitable for open surgery [10]". It involves the precise target destruction that containing tumors or neural structures, without damage to the adjacent tissues.

"Professor Lars Leksell first coupled an orthovoltage X-ray tube with his first-generation guiding device to focus radiation on the Gasserian ganglion to treat facial pain". He subsequently

investigated cross-fired protons as well as X-rays from an "early-generation linear accelerator (linac)" for radiosurgery. "In the 1960s, he became dissatisfied with the cumbersome nature of cross-fired proton beams and the poor reliability and wobble of then-existing linear accelerators". Leksell and Larson finally selected cobalt-60 as the ideal photon radiation source and developed the Gamma Knife. They placed 179 CO-60 sources in a hemispherical array so that "all gamma rays (radiation from decay of CO-60) focused on a single point thereby creating cumulative radiation isocenters of variable volume depending on the beam diameter the first Gamma Knife created a discoid-shaped lesion suitable for neurosurgical treatment of movement disorders and intractable pain management" [11] and [12]. In 1967, the Clinical work with the Gamma Knife began at the manufacturing site, the Motala AB workshop near Linköping in Sweden. The first patient had a craniopharyngioma. "The patient's head was immobilized using a plaster-molded head-piece. In 1975, a series of surgical pioneers at the Karolinska Hospital, Stockholm, began to use a reengineered Gamma Knife (spheroid lesion) for treatment of intracranial tumors and vascular malformations" . [12] Units 3 and 4 were placed in Buenos Aires and Sheffield England in early 1980s. "Lunsford introduced the first clinical 201-source Gamma Knife unit to North America (the fifth gamma unit worldwide). Lunsford first performed Gamma Knife radiosurgery in August 1987 at University of Pittsburgh Medical Center. In the United States, based on the available published literature, arteriovenous malformations (AVMs) and skull base tumors that failed other treatments were considered the initial indications for radiosurgery" . [11-15] A cautious approach was adopted while waiting for increased scientific documentation. "The encouraging results of radiosurgery for benign tumors and vascular malformation led to an exponential rise of radiosurgery cases and sales of Radiosurgical units". In recent years, brain tumors(metastatic) and Trigeminal Neuralgia have become the most common indications for radiosurgery .[16-20]

A modern definition has been approved in the USA. "The AANS Board of Directors, the Executive Committee of the Neurological Surgeons Congress and the Board of Directors of the American Society for Therapeutic Radiology and Oncology agreed on a contemporary definition of stereotactic radiosurgery, as "Stereotactic radiosurgery is a distinct discipline that utilizes externally generated ionizing radiation in certain cases to inactivate or eradicate (a) defined target(s) in the head and spine without the need to make an incision. The target is defined by high-resolution stereotactic imaging. To assure quality of patient care the procedure involves a multidisciplinary team consisting of a neurosurgeon, radiation oncologist, and medical physicist." . [21-25]

Recently, "Stereotactic neurosurgery has evolved rapidly with the development of the computed imaging systems, the advances in the understanding of disease pathophysiology, the discovery of new therapeutic targets, the increasingly widespread use of neurophysiological technology" . [26-30]

Gamma knife stereotactic radiosurgery is the best choice now days for its better results in treating multiple diseases.

Aim of the Study

To assess the efficiency of gamma knife treatment outcome of Iraqi patients who are suffering from primary TN (Trigeminal Nerve) and irradiated with a dose of 80 Gy and/or 89 Gy (recommended by gamma knife society with a dose range of 80-125 Gy), and to evaluate the change in nerve thickness.

Methodology

Patients:

1. Inclusion Criteria: This study included (8) patients, their age range was (40 to 62) years. All patients were diagnosed by neurologists and neurosurgeons as having primary TN, they showed no response to medications (full dose of medication) , some of them can't be subjected to microvascular decompression surgery or had previously treated by GK or MVD with pain recurrence.

2. Exclusion Criteria: patient who had secondary TN and the psychologically unstable patients were excluded from this study

Before the patient receive any treatment, patients divided into two groups according scores as IV and V. Most patients are BNI V. The characteristics of table (1).

Table (1) characteristics of patients included in the study

Age range	40-62)years)
Irradiation Dose	
Dose 80 Gy	N = 1
Dose 89 Gy	N = 3
Dose 90 Gy	N = 4

Procedure of patient's preparation prior to treatment:

The patient's preparation procedure involved the following steps to ensure that the treatment is achieved properly:

a. Stereotactic Frame Application: This step includes the frame fixation on the patient's head to make the beams of the source focused exactly where the treatment is needed as shown in figure (3 .1).

Figure 1: Stereotactic Frame Fixation (Neuroscience Hospital GK Center, Baghdad, Iraq)

The frame was marked with a rectilinear coordinate scale (X, Y and Z) measured in millimeters, about (0 to 180) mm. This scale should conform the X, Y and Z directions of CT or MR scanning.

The Cartesian axis (X, Y, Z = 0) are located outside the Frame at the superior point, lateral and posterior to the frame on the patient's right side, as shown in figure (2).

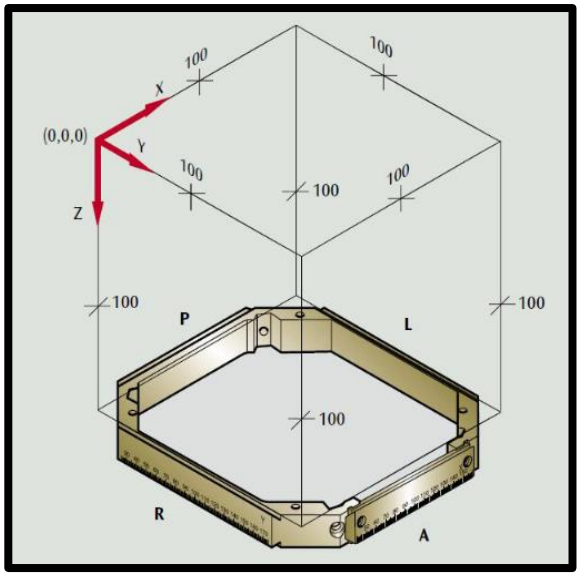

Figure3.2: Leksell's Coordinate System. L= left, R= Right, P=Posterior, A= Anterior. (GK manual)

The magnetic resonance (MR) indicator box was used during frame fitting to ensure a comfortable, accurate fit during imaging. Then, the treating doctor verified the correct diagnosis, and appropriate site of treatment.

b. Anesthesia:

Local anesthetic called lignoaine without adrenaline used before a frame's screws fixation . A needle filled with 5cc local anesthetic agent used fir every two sites of screw fixation , as show in (Figure. 3.3).

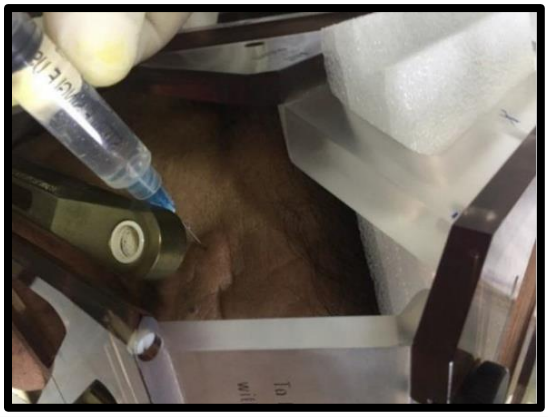

Figure (3): Injection of local anesthesia to the patient in the front (Neuroscience Hospital Center, Baghdad, Iraq)

c. Frame's screw fixation: Pre- the frame fixation procedure, patient's education is a key component. Each patient was oriented about what to be anticipated in regard to sensations such as

pressure during tightening of fixation screws to assist in managing anxiety. This was done by allowing
individuals to view photos of previous patients, wearing the device, or
coordinate patient-to-patient contact with previous radiosurgery candidates.
The screws were fixed tightly and diagonally with avoiding of over tightening as shown as show in figure 3.4, all screw tips were sterilized before and during the procedure and skin antisepsis using sterilizer solution . Then, for each fixation position the screws of fixation were selected according to the patient's head dimensions **.** the screw was inserted in the threaded hole of the frame, frame fixation was checked to ensure if it firmly attached to the patient's skull by grabbing it and gently lifting it[31-35].
All individuals in the fixation room were versed with emergency procedures in case of respiratory depression and vasovagal condition.

Figure .4: Frame fixation on the patient's head (Neuroscience Hospital Center, Baghdad, Iraq)

d. The Frame Cap Fit: This process was done to know that the patient's head or the frame will not collide with the interior of the Gamma Knife during treatment , to ensure that if the frame box was attached to the frame with no conflict between the head , posts or pins and the plastic box. Then, in most situations the patient would fit in the Gamma Knife Perfexion , as shown in figure (3.5).

Figure 3.5: Checking of frame cap fitting (Neuroscience Hospital Center, Baghdad, Iraq)

e. Fitting the indicator: Two types of Leksell Gamma Knife indicators were used, one for MRI and the other for CT examinations. The indicator is a cap contain material that allow to show fiducials on CT or MRI images. MRI indicator contains copper-sulfate solution of (0.25 L) in the N shape gap as shown in image (3.6).

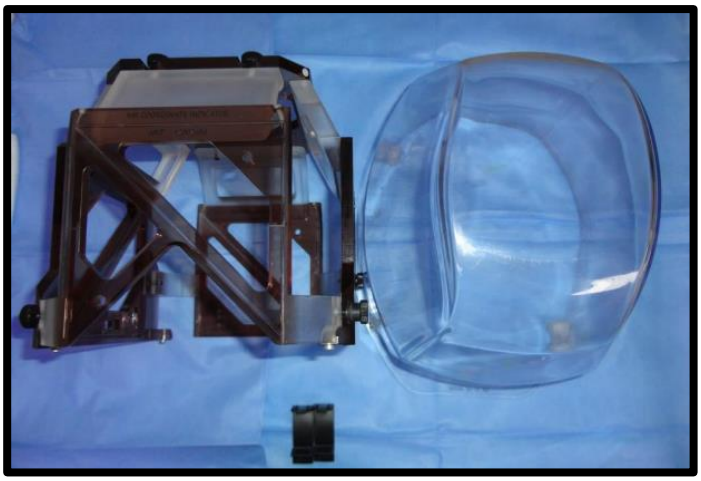

Figure 6: MRI Indicator containing copper-sulfate solution (Neuroscience Hospital Center, Baghdad, Iraq)

f. Radiographic Imaging: After the step of frame fitting, the patient was moved the imaging unit to image the patient's brain by MRI (figure. 3.7). The produced images checked by the radiologist to ensure that it was of good resolution, with no distortion and it provided a complete slice for the examined part of the lesion. Then, these images transferred to the LGK planning computer.

Figure. 7: GK Patient's head coil used for MRI imaging technique (Neuroscience Hospital Center, Baghdad, Iraq)

Result and dissusion

After finishing the MRI examination, images were transported to planning work station to start the Radiosurgical planning which can be considered as the constructions of isodose shells and a choice of dose so that the target receives as high a dose as possible while the surrounding healthy tissue and critical organs keeps safe. It's a combination of clinical judgment and a technical task. The treatment planning included the following procedures: This step included the identification of the target to be treated. For Gamma Knife planning, the scalp of the patients was measured with a skull-scaling device, the location of the surface was determined for computing the penetration depth for each beam during the dose

calculation. The skull-scaling device used for Gamma Knife planning makes it possible to know the penetration depth for each photon beam even if the entire skull has not been imaged

Then on GK computer, patient information entered including his name, age, disease, date of treatment, operator, patients code, and skull measurements to draw 3d skull of the patient which will be filled with MRI images,

Image registration: The general planning procedure started with the acquisition of three-dimensional image information and the import of patient images into the treatment-planning system via a computer network or data storage media. On the planning computer, these acquitted images were typically displayed in two-dimensional slices along the axial, sagittal, or coronal planes[36,37]**.**

3. Measurement of Trigeminal nerve thickness: The nerve thickness was measured by the Line option of the GK software and recorded before selecting the treating dose value as shown in figure (3.10).

Figure 8: Nerve thickness measurement in GK planning computer (Neuroscience Hospital Center, Baghdad, Iraq)

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4. Prescribed treatment dose: This included the input of the prescribed dose (80 or 89) Gy by the plan of the Linux software of GK in single shot. The dose of 80 Gy considered as a minimal dose to produce pain control effect as GK Society recommended, and its applied in Neuroscience Hospital Center, Baghdad, Iraq

5. Determination of the target's Isocenter:

The technical goal of trigeminal neuralgia SRS is to place a radio surgical 4mm isocenter onto the trigeminal nerve as it runs through the prepontine cistern.

The rationale for placing the isocenter within the prepontine cistern is that the nerve can be well visualized on MRI in this area, and that the nerve is also surrounded by cerebrospinal fluid, allowing for the precise targeting and sharp dose falloff (i.e., penumbra) beyond the nerve, minimizing the risk of damage to surrounding structures such as the brainstem and temporal lobe. A sample Radiosurgical plan is demonstrated in Figure (9).[37-39]

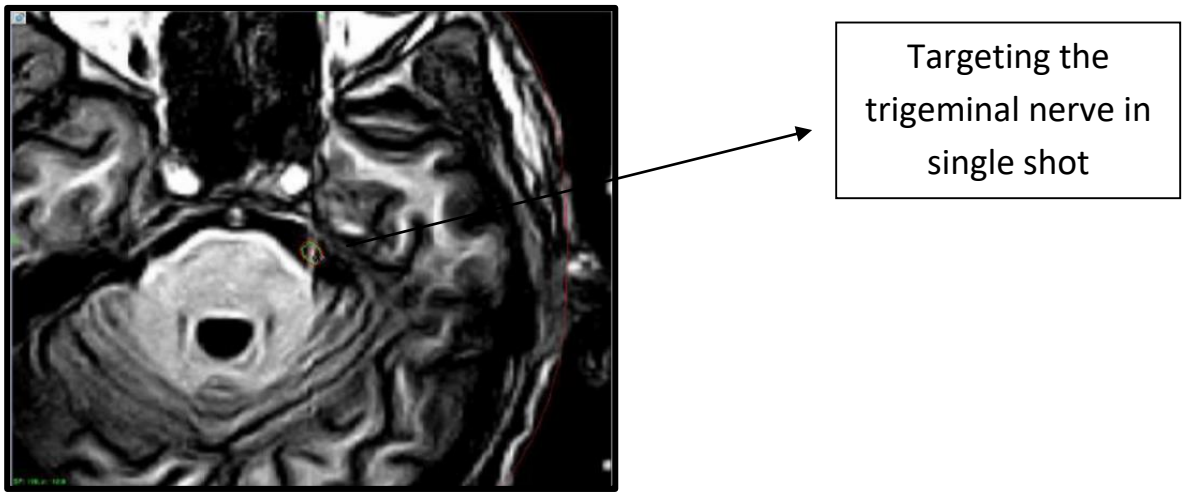

Figure 9: Targeting of left trigeminal nerve

Dose Modulation:

This step was done to get more patient's treatment safety, where the use of sector channels "Plugging" of GK device block dose from the brainstem and delivering dose to a greater length of

nerve. The weight of the shot was reduced or increased to get more protection to the critical organs as shown in figure (10)

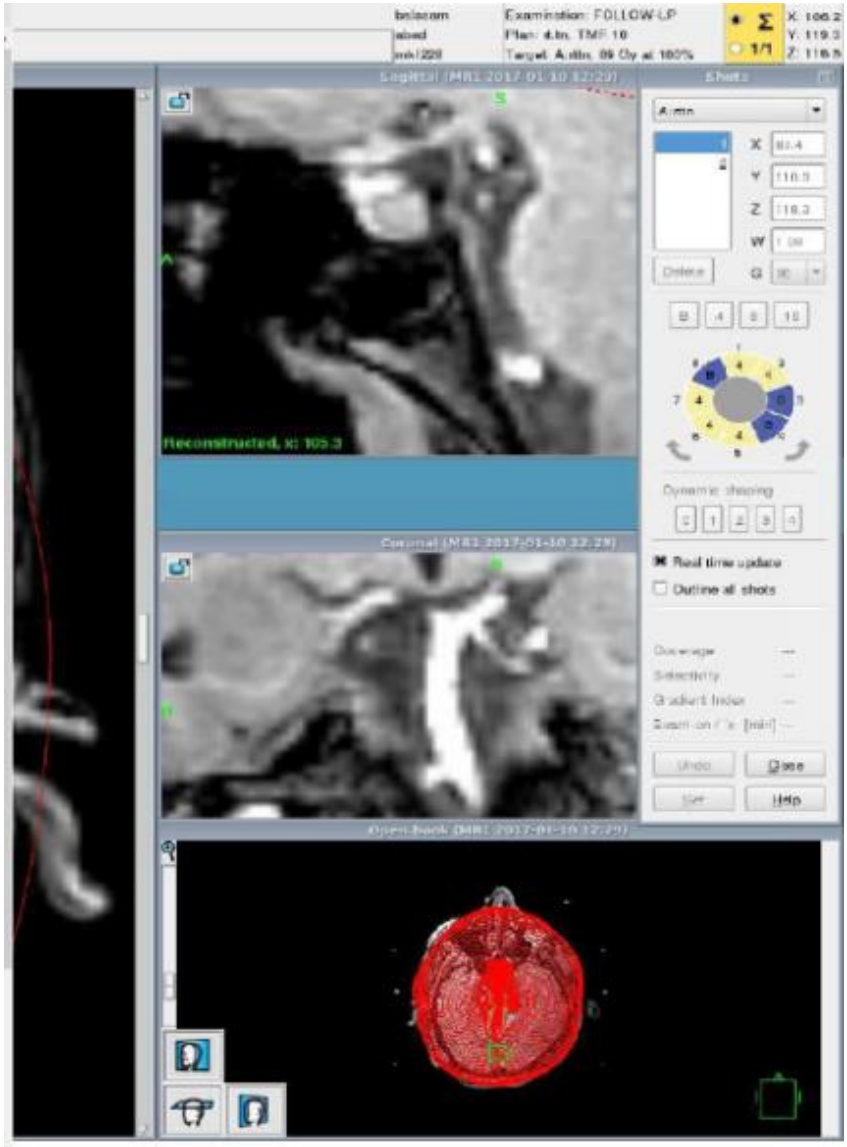

Figure 10: The use of plugging blocks and weight of GK to reduce the dose to the healthy tissue (Neuroscience Hospital Center, Baghdad, Iraq)

Patient Irradiation: Finally, after plan approving, protocol printing and data exporting to LGK treatment console. The patient's treatment data was entered on the data base system. Then, the complete patients' data was imported into LGK treatment control system, then patient lied on the device couch to receive the radiation treatment.

Patients' Follow-Up:

Three weeks' follow-up:

Three weeks post treatment; assessment was done by the BNI scores to know the effect of radiation on nerve function. The medication that was prescribed for the patient before GK treatment remains the same through 3 weeks post GK, where all patients routinely asked and examined by the treating neurosurgeon for the intensity of pain, pain relief, and any other dysfunction of trigeminal nerve. The medication might be changed according to the patient's level of health improvement.

Three months' follow-up:

After three months, a new MRI image was taken to evaluate the nerve thickness changes and any other complications that might occur after irradiation by GK. Then, images of pre-and post GK were fused by a software option which is termed "co-registration", by activating this option, both of the images information would combine, and the differences between them was shown. The nerve measurement was recorded, and the patient's BNI scores was re-evaluated. If the nerve thickness increased due to edema effect, that means the nerve tissue responded to radiation treatment[40-43].

Conclusion

Gamma rays are considered to be the most dangerous radiation in the electromagnetic field, since they possess the highest energy because of their high frequency.

As for their uses, they are used in the medical and industrial fields, but in very small quantities. The doses of radiation given to the patient are calculated so accurately that they destroy the cancer cells. The healthy body cells regain their health after recovery and can follow the course of the body's vital processes. Also here in the project we have worked on measurements of the effect of radiation on the workers in this area where there is no effect on the workers outside the room when the device is operating and give radiation to the patient because the room is completely isolated from the arrival of any radioactive effects harmful to workers.

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