The Enhancement in Meningioma Brain Tumor for Single Session Patient's Treatment Via Gamma Knife Radiosurgery (GKS)

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Abstract

Gamma knife is the most effective radiotherapy technique in eliminating brain tumors, including meningioma, and its effectiveness is comparable to brain surgeries, as meningioma is estimated to be one of the common benign tumors that occur in people, and many of them are usually asymptomatic. They are derived from arachnoid cap cells, which are cells found within the thin, spider web-like membrane that protects the brain and spinal cord. The arachnoid is one of three protective layers that surround the brain and spinal cord, commonly known as the meninges. The dura mater and pia mater are the meninges' other two layers. These tumors can grow slowly until they are very large, if left undiscovered, and, in some locations, can be severely disabling and life-threatening. Other forms of meningioma may be more aggressive. Most patients develop a single meningioma; however, some patients may develop several tumors growing simultaneously in other locations of the brain or spinal cord, Leksell Gamma Knife has focused beams of radiation directed to the brain's treatment area. The treatment procedure is simple, painless, and straight forward, allowing minimizing the dose of radiation to nearby critical structures. Aim of study: - The research's primary goal is to obtain control of meningioma's growth (size control). Furthermore, this research aims to accomplish significant reductions in tumor size just with single session, such that fast recovery equals short treatment duration, and eventually to achieve full tumor removal, as well as to do radiosurgery just once. Patients and Method This is a cohort (prospective) design study , consist of 35 patients ,(5male and30 female) age from(45 t0 60)exposure to single session of radiation of gamma knife radio surgery period from Dec2021 to October 2022 to treated by Gamma Knife radiosurgery, with prescribed doses at (50%) range from 10Gy to14Gy, three patients exposure to 10Gy and 10 patients get 12 Gy,22 patients get 14 Gy with tumor diameter from (15 mm to 30 mm). Result:- After six months of follow -up , study show decrease in tumor size in varying ratio For all patients at 50% 14Gy ,12Gy and 10Gy , the rate of disappearance of meningioma was 3/35 post GKR with prescription dose at 50% 14Gy , and ratio of decrease in size (9.6% ,16% and 17%) for patients given at 50% 10 Gy , at dose 12Gy the improvement in tumor size ratio for nine patients is 10%, 11% ,21%,25%,26%,27% ,31%,36%,41%. and one still in same size. Conclusion Based on the our preliminary findings, gamma knife radiosurgery appears to be a safe and effective main therapeutic option for tumor growth control, potentially improving overall outcomes in patients with Meningioma 2- It is also a successful adjuvant treatment for tumors that are surgically inaccessible and individuals who are at increased risk from open surgery By the end of this study, all tumors responded significantly, with improvement in vital signs

Keywords: Meningioma, stereotactic magnetic resonance imaging , Leksell Gamma knife radiosurgery, single session.

1. Introduction

Meningioma is the most common benign tumor treated with Gamma Knife surgery (GKS). It is the most prevalent intracranial neoplasm, accounting for 25-33% of all primary brain tumors in adults.

Meningioma is non-inflating (circumscribed) and occurs most frequently in middle-aged and older individuals aged 45-65 years, with a 2:1 incidence rate in females rather than men and rarely in children (1).

They originate from arachnoid cap cells, which are cells within the thin, spider web-like membrane that covers the brain and spinal cord. The arachnoid is one of three protective layers, collectively known as the meninges, which surround the brain and the spinal cord. The other two layers of the meninges are the Dura mater and pia mater. Although the majority of meningioma is benign, these tumors can grow slowly until they are very large, if left undiscovered, and, in some locations, can be severely disabling and life-threatening. Other forms of meningioma may be more aggressive. Most patients develop a single meningioma; however, some patients may develop several tumors growing simultaneously in other locations of the brain or spinal cord (2).

Meningioma susceptibility is thought to be inherited, according to both family history and candidate gene research on DNA repair genes. People who have specific mutations in the NF2 neurofibromatosis gene have a greatly increased risk of developing meningioma. Meningioma occurrence risk has been linked to ionizing radiation exposure at high doses,

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but the precise types and amounts that increase risk are still disputed or poorly understood (3).
Meningioma expresses numerous hormone receptors, including (progesterone, estrogen, and testosterone), There is a growing body of knowledge regarding the particular roles that each hormone receptor may play in meningioma growth (4).

Patients and Methods

Study design

This is a cohort (prospective) design study to show the effectiveness of the single session dose of the gamma knife radiosurgery in enhancement in meningioma tumor size.
Study setting: This research has been performed at the Gamma knife center of Neurosciences Hospital, Baghdad/Iraq. Information of the patients was gatherers in Dec 2021, with a follow up at the research center of magnetic resonance imaging is (6)months , The investigations have been performing for all patients in the advisory office of the college of medicine, Al-Nahrain University.

Study population: Study consist of 35 patients ,(5male and30 female) all patients without any remove tumor operation, age from(45 t0 60)exposure to single session of radiation of gamma knife radio surgery, with prescribed doses at (50%) range from 10Gy to14Gy, three patients exposure to 10Gy and 10 patients get 12 Gy,22 patients get 14 Gy with tumor diameter from (15 mm to 30 mm).

Study variables: Doses (Gy), removal operating, months after gamma knife radiosurgery, size of meningioma pre and post-GK.

Data collection method & instrument

Data collection: The phone numbers of the patients and the data of their radiosurgery at the Gamma knife (GKR) center of Neurosciences Hospital, Baghdad/Iraq have been collect. The patients contacted to obtain their approval on including them in the research. After approvals were obtaining, the Pre-GK operation MRI reports, age, also if underwent surgical intervention or not, all were collected from all the patients .The MRI report for all participants post-GKR.

Instrumentation: stereotactic magnetic resonance imaging (MRI) and
Computed tomography CT

Gamma knife unit

To treat complex, challenging brain problems, a non-invasive stereotactic radio surgical tool that does not require a knife or incision is used instead of intricate brain interference. When compared to conventional therapy, stereotactic radiosurgery (SRS) can deliver precisely focused radiation in fewer high-dose treatments while sparing healthy tissue. SRS is known as stereotactic body radiotherapy (SBRT) when it is used to treat body malignancies. (5).

Stereotactic radiosurgery (SRS) was developed by combining neurosurgery with radiation oncology. Stereotactic radiosurgery (SRS) is a technique for delivering a single high-dose fraction of ionizing radiation to a precisely defined focal target volume (6).

In order to execute stereotaxic, a stereotactic head frame for GK-SRS is used to fix the patient's alignment to a physical coordinate system.
The words "stereo" and "taxy," which have Greek roots, respectively, denote "solid" and "arrangement," but the principle of stereotaxis is the region of interest in the brain(7).
This method aids in the three-dimensional Cartesian axis system through frame localization of deep brain tissue.
The Perfexion and later-developed Icon, the most recent iterations of the Gamma Knife, were developed specifically to facilitate radio surgical therapy. The most effective method for administering stereotactic radiosurgery to the brain is GK-SRS. (7,8).

Ethical approvals: Before collecting data, the researcher takes approval from the Department of Gamma Knife Center in neuroscience hospital. Each participant has written a consent that was already done by the Gamma Knife center. All information about patient participants was kept confidential.

Statistical analysis

The data were processed using SPSS version 16.0.0, Microsoft Excel 2010, the data of the current study were scrutinized carefully in terms of being parametric or non-parametric using normality tests. Accordingly, the proper statistical tests were used. Student t-test and ANOVA test were used for parametric data and the Mann-Whitney test was used for non-parametric data to measure the significance of the difference in means taking into account whether variables of analysis sharing different or equal variance.

2. 3- Results

This includes the results of thirty five patients (30 females & 5 males) with age range from (45-60)of meningioma treated by Gamma Knife radiosurgery with single session used prescribed doses at 50% from 10 Gy to 14 Gy see table(1) below, summarizes descriptive statistics of single session Population of patients' data after six months of follow up that included

The effect of prescribed doses on meningioma's size post Gamma radiosurgery

Three patients exposure to dose at 50% 10Gy with decreased in size of tumor as shown described in table ,ten patients with given dose at 12Gy with decreased in size and one in same size,the tumor disappear with three patients given dose 14Gy at 50% and decrease in other

(19) patients .

Table (1): - Descriptive statistics of patients' data for single session of Gamma knife surgery for Meningioma treatment						
No of patient	Age and Gender	Date of surgery	Dose in Gy	Volume before session In (mm3)	Volume after follow up six month	Percentage of enhancement %
1	56/M	2022	14	37662	32712	13%
2	49/F	2022	12	6634	4570	31%
3	50/F	2022	10	20608	17173	16%
4	48/F	2022	14	12442	7515	40%
5	53/M	2022	14	12507	8691	30%
6	52/F	2022	14	4677	3055	35%
7	51/F	2022	14	9779	7550	22%
8	54/F	2022	12	2870	2253	21%
9	53/F	2022	12	1115	993	10%
10	61/F	2022	12	1462	1299	11%
11	60/F	2022	14	9477	8761	7%
12	57/F	2021	12	1106	644	41%
13	56/F	2021	12	2803	1875	25%
14	48/F	2021	12	4902	3561	27%
15	49/F	2021	14	3851	3174	18%
16	51/M	2021	14	18493	Tumors disappear	100%
17	56/F	2022	14	1530	80	94%
18	54/F	2022	14	5868	Tumors disappear	100%
19	49/F	2022	10	887.8	802.4	6 %
20	52/F	2022	14	2748	1314	52%
21	50/F	2022	10	10809	8898	17%
22	48/F	2022	14	14111	7875	53.9 %
23	51/F	2022	14	40565	23805	41%
24	53/F	2022	12	1065	784	26%
25	54/F	2022	14	5170	4536	12%
26	50/M	2022	14	22675	15960	30%
27	56/F	2022	14	2668	2054	23%
28	57/F	2022	12	637	401	36%
29	62/F	2022	14	4446	3480	21%
30	65/F	2022	14	9919	5750	43%
31	54/F	2022	12	2489	2489 (No change)	0%
32	45/F	2022	14	29683	19740	33%
33	47/M	2022	14	15909	12399	22%
34	63/F	2022	14	34056	24640	27%
35	60/F	2022	14	5397	Tumor disappear	100%

According the table (2) below show change in size at 50% dose 10Gy
with mean & ± standard deviation before GKS (10768 ± 9860) and can see after GKS with mean & ± standard deviation (8956± 8185) , at 50% dose 12Gy
with mean & ± standard deviation before GKS 5427.09±4943 ,After GKS can see
with mean & ± standard deviation (4281±3132) , at dose 14 Gy before GKS with mean & ± standard deviation (13939±11935) ,after GKS mean & ± standard deviation is (8776±9170) , with p-value significant 0.04.

Table (2):- the changes in tumor size (mm3) pre and post GKR according doses			
Dose	Tumor size before (mm3) Mean ±SD	Tumor size after (mm3) Mean ±SD	P-value
10Gy	10768±9860	8956±8185	0.04 Significant
12Gy	5427.09±4943	4281±3132	
14Gy	13939±11935	8776±9170	

In figure (1) below shows that all patients benefited from the treatment, and that the large sizes of meningioma were exposed to the highest dose of radiation at 14, with the highest rate of response and improvement in size.

The enhancement percentage of meningioma's patients

After six months of follow -up , study show decrease in tumor size in varying ratio For all patients at 50% 14Gy 12Gy and 10Gy , ratio of decrease in size was 9.6% ,16% and 17% for three patients given at 50% 10 Gy see figure(2) below.

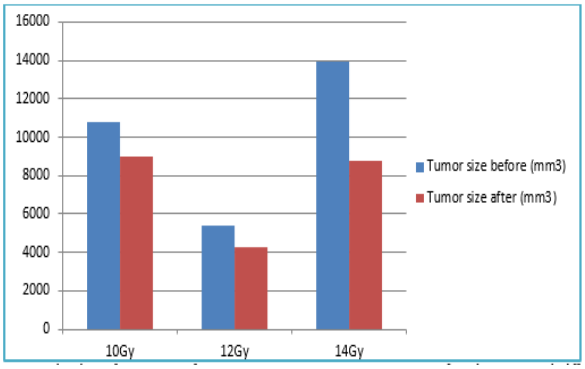

Figure (1): - The chart of mean sizes of Meningioma tumors pre & post-Gamma Knife radiosurgery with different doses for single session

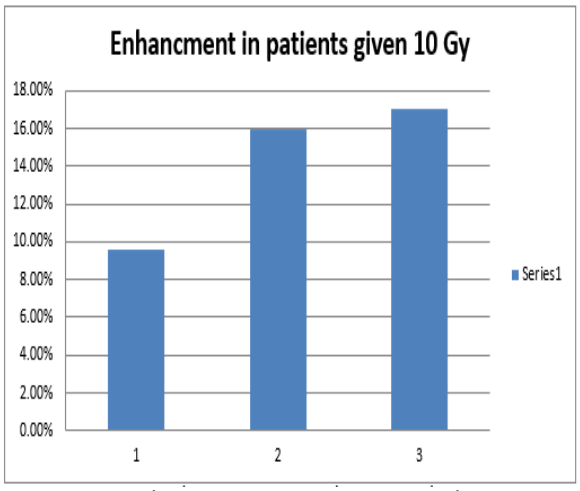

Figure (2):- Enhancement percentage at dose 10Gy in single session

In figure (3) below show the ten patients given dose at 50% 12Gy, one patient see the no noticeable improvement in size, and improvement in tumor size ratio for nine patients was 10%, 11% ,21%,25%,26%,27% ,31%,36%,41%.

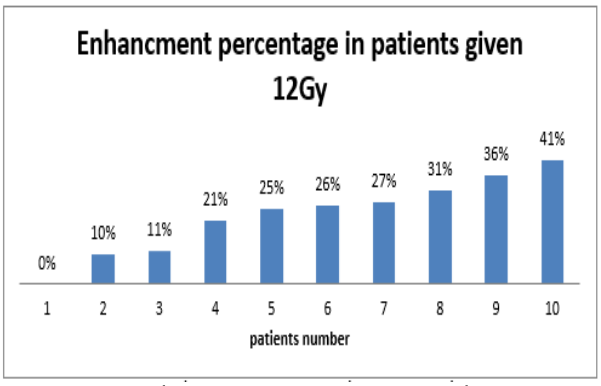

Figure (3):- Enhancement percentage at dose 12Gy in single session

In figure(4) below show the improvement in tumor size for (22)patients at 50% dose 14 Gy , the rate of disappearance of meningioma was 3/22 post GKR with enhancement 100% , (9)patients with ratio of improvement (7%,12%,13%,18%,21%,23%,27%,33%,35%) ,two patients with percentage (22%) improvement in size, and other two patients with (30%)percentage, and three patients with(40%,41%,43%)percentage and two patients with(52%,53%)percentage and one (94%)percentage.

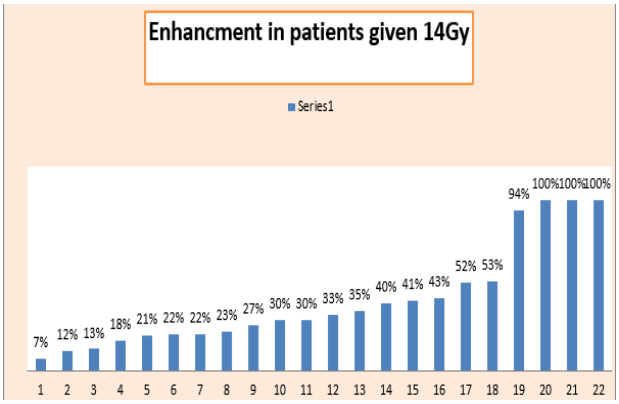

Figure (4): Enhancement percentage at dose 14Gy in single session

3. Discussion

In this study, multiple prescription doses were used, and all were sufficient to elicit a change in tumor growth after one session. However, this study indicated that the speed of recovery differs from patient to patient depending on whether the tumor was benign or malignant, as it was found that two patients with the same volume and the same dose, one of them responded and the other did not respond to radiation

By the end of this study, all tumors responded significantly, with improvement in vital signs.

Conclusion

1-Based on the our preliminary findings, gamma knife radiosurgery appears to be a safe and effective main therapeutic option for tumor growth control, potentially improving overall outcomes in patients with Meningioma

2- It is also a successful adjuvant treatment for tumors that are surgically inaccessible and individuals who are at increased risk from open surgery

Reference

1- Louis DN, Perry A, Reifenberger G, Von Deimling A, Figarella-Branger D, Cavenee WK, Ohgaki H, Wiestler OD, Kleihues P, Ellison DW. The 2016 World Health Organization classification of tumors of the central nervous system: a summary. Acta neuropathologica. 2016 Jun;131(6):803-20.

2- Marosi C, Hassler M, Roessler K, Reni M, Sant M, Mazza E, Vecht C. Meningioma. Critical reviews in oncology/hematology. 2008 Aug 1;67(2):153-71.

3- Wiemels J, Wrensch M, Claus EB. Epidemiology and etiology of meningioma. Journal of neuro-oncology. 2010 Sep;99(3):307-14

4- Haines DE, Frederickson RG. The meninges. In: Al-Mefty O, ed. Meningiomas. New York: Raven Press; 1991:9.

5- Ganz JC. The history of the gamma knife. Elsevier; 2014 Oct 30

6- Mathieu D, editor. Gamma Knife Radiosurgery. BoD–Books on Demand; 2011 Dec 16.

7- Leksell D. The origins and development of radiosurgery and the Leksell

8- Fallon K, Kim JO, Bednarz G. Medical Physics for Leksell Radiosurgery. InLeksell Radiosurgery 2019 (Vol. 34, pp. 48-56). Karger Publishers