Effect of Gamma Knife Radiosurgery in Meningioma

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ABSTRACT:

BACKGROUND:

Meningioma is a common disease affects middle age patients especially females. Surgery is the first choice of treatment, gamma knife usually is a treatment for residual tumor or sometimes initially when surgery is risky.

OBJECTIVE:

To evaluate the short time effectiveness of gamma knife in treatment of meningioma with associated complications including necrosis and edema and assessing factors that favor success

PATIENTS AND METHODS:

A retrospective study from April 2017 to October 2017 in Neurosciences hospital of 35 patients, 25 female and 10 male, age range 36-70 years, brain MRI done before and 6 months after gamma knife, patients evaluated regarding type of meningioma, number of shots, edema and radiation dose

RESULTS:

The most common types were parasagittal and convexity meningioma, size of tumors ranged from 10mm to 57mm most tumors were 20-29mm, post-gamma necrosis was higher in non-basal meningioma (76.5%) than basal meningioma (44.4%). Necrosis appeared 100% when using > 18 Grey. The necrosis decreased when using doses 14-16 Grey and 10-12 Grey. Non-basal meningioma showed high edema (47.1%) while basal showed less edema (38.9%), higher doses of radiation associated with more edema. Headache improved post-gamma.

CONCLUSIONS:

Gamma knife is effective and safe option to treat meningioma when surgery is risky, the tumor necrosis is highest in non-basal meningioma and when the dose above 14 grey and the peritumoral edema was highest also in non-basal meningioma and when the dose of radiation above 18 grey.

KEYWORDS: Meningioma, Gamma knife surgery, Stereotactic radiosurgery

INTRODUCTION:

Meningiomas: A meningioma is, in many ways, the soul of neurosurgery. The progress in meningioma treatment mirrors advances in neurosurgery, and advancements in neurosurgery are put to maximal use to improve the treatment of meningiomas. The incidence of meningioma is 22% of primary intracranial tumors.[1]

The cell of origin of meningiomas is believed to be the arachnoid cap cell. Meningiomas are usually globular, encapsulated tumors. The distribution of intracranial meningiomas is approximately as follows: convexity (35%), parasagittal (20%), sphenoid ridge (20%), intraventricular (5%), tuberculum sellae (3%), infratentorial (13%), and others (4%).[2]

Radiologically, Meningiomas usually enhance intensely and uniformly after the injection of gadolinium, with typical dural tail enhancement.[3]

Radiation therapy:

Radiation therapy should be considered following surgery for a malignant meningioma, following incomplete resection of a meningioma for which the risk of resection of an eventual recurrence is judged to be excessive.[4]

Radiosurgery

First-line radiosurgery is recommended for a cavernous sinus meningioma when it is small enough and far enough from the optic pathway.[5] When the lesion is too big or too close to the optic pathway, a combined approach (resection of the portion outside the cavernous sinus) or conventional radiotherapy is advocated.[6] Petroclival meningiomas may be excellent indications for radiosurgery,

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especially when they are growing, are causing few clinical signs, and are small enough to be treated with lower morbidity than possible with microsurgery.[7]

Doses less than 12 Gy have been reported to be a significant factor in failure to control meningioma growth.[9] Recommended 12 to 14 Gy for tumors larger than 3 cm, 16 Gy for tumors 1 to 3 cm, and 18 Gy for tumors smaller than 1 cm.[10] The tolerance of the second through sixth cranial nerves of radiosurgery, they found a higher incidence of optic pathway damage in patients receiving more than 10 Gray to any part of the optic apparatus.[8]

Tumor Response

Long-term follow-up is also needed for evaluation of tumor response in view of the slow growth of a large number of meningioma. In a cohort of patients treated conservatively, that lack of hyper intense tumor signal on T2-weighted MRI sequences and presence of calcifications were predictive of slow growth, whereas per focal edema was associated with the potential for more rapid growth.[11]

Tumor Control

Most series indicate excellent results in terms of tumor control, rates of which range between 86.7% and 100%.[12] The rates of stabilization and regression of tumor size after Gamma Knife radiosurgery are diverse. Several series report a 60% rate of decreasing tumor size and a 40% rate of tumor stability[13] whereas others indicate that in only 13% to 16% of patients does the tumor decrease.[14] In this latter report, mean size reduction of benign meningiomas was 16.1% and mean response rate was highest for those in the cavernous sinus location. The heterogeneity of results may be due to different ways of evaluating tumor behavior. Huge variations in the duration of follow-up may also explain these heterogeneous results. patients could be “late responders,” with the tumor starting to shrink more than 4 years after radiosurgery.[13]

Functional Outcome

Neurological improvement after SRS can be expected when the deficits are incomplete and of recent onset. This improvement or recovery has been reported in 14% to 48% of patients..

Although nonspecific symptoms like headaches and vertigo can disappear after SRS,[17] the most dramatic effect involves the cranial nerves. Trigeminal neuralgia improves in 13% to 91% of cases, third nerve deficit in 17% to 67%, and abducens nerve deficit in 21% to 71%.

Abducens nerve deficit improved after SRS in 60% of patients with petroclival tumors and in 42% of patients with parasellar meningiomas.[7] These recoveries may or may not be linked to tumor shrinkage. The probabilities of recovery from optic pathway deficit and from trigeminal hypesthesia are low. The toxicity from radiosurgery of meningiomas comes mostly from symptomatic edema or damage to cranial nerves. In the majority of cases, the morbidity is temporary and rarely disabling, although permanent complications have been reported in 2.5% to 9% of cases. The risk of postradiosurgery sequelae was lower in patients treated after 1991, a time that corresponded to the routine use of stereotactic MRI during treatment planning as well as reduction of delivered radiation doses.[15] Post-irradiation edema has been correlated with tumor location. Patients with parasagittal,[7] parafalcine, and anterior fossa tumor locations are at risk.[15] Malignant and atypical meningiomas are clearly more likely to fail to respond to radiosurgery.[18] Hemangiopericytomas frequently manifest much like meningiomas from a radiologic point of view but are usually much more sensitive to radiosurgery[15]

PATIENTS AND METHODS:

This is a clinical retrospective study conducted at neuroscience teaching hospital, gamma knife department.

Thirty five cases of meningioma 10 males and 25 females were conducted since March 2017 to September 2017. They were followed up after gamma knife for six months.

History and examination done for all the patients. Routine investigations were performed for all patients, as complete blood count, ESR, random blood sugar and blood urea. All patients were obtained 3 tesla brain MRI study with contrast prior to gamma knife. Most patients were diagnosed with meningioma radiologically and few admitted post-surgery for a residual mass.

Then performing gamma knife by a procedure mentioned below, patients were discharged from the hospital on the next day.

All patients examined 21 days post gamma knife to assess the complications and then another visit at 6 months later were they asked to perform new MRI to observe radiological changes.

Radiation induced tumor necrosis were defined as heterogeneous mixed intensity observed in tumor. Radiologically Peri-tumoral edema assessed to be mild (around the tumor), moderate (involve one lobe) or severe (involve more than one lobe). Headache was assessed post treatment in all patients.

Procedure

Under local anesthesia with lidocaine 2% before Leksell Frame was applied to patients' heads. Calibration of distance of the frame with special helmet. Patients were asked to obtain new MRI study with Leksell frame, then image fusion were performed with pre frame MRI and patients were asked to enter Gamma knife helmet. Localization of tumor by software and targeting the tumor. The dose was applied according to schedule and surgeon preference with shielding of vital structures and radiation emitting to patients were performed

RESULTS:

Age distribution:

The majority of the patients treated by gamma knife in our study is between (40-49) years old. Figure (2).

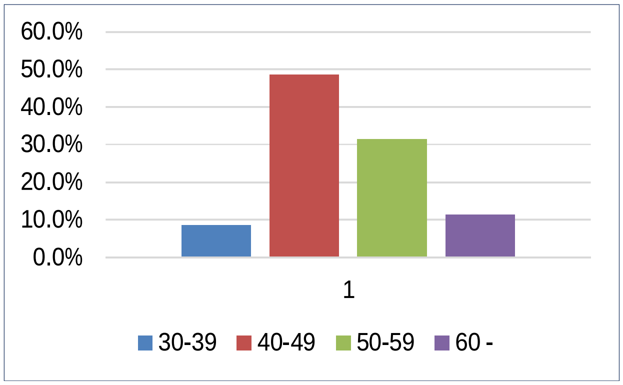

Figure 4.1: Age distribution of patients treated by gamma knife

Specific location of meningioma:

Specific types of meningiomas treated with gamma knife in our study are shown in figure (3). The majority were convexity and parasagittal meningioma.

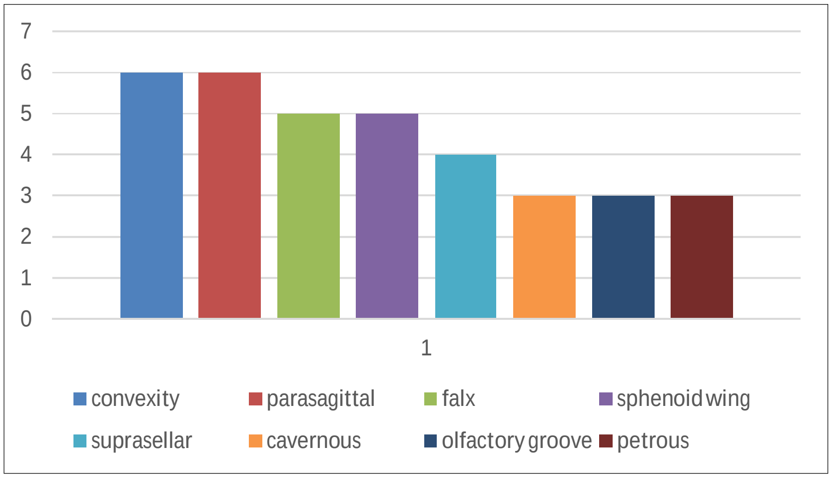

Figure 4.2 shows the types of meningioma treated with gamma knife

Size of meningioma:

Size of meningioma treated with gamma knife ranged from (10-57) mm radiologically as shown in figure (4).

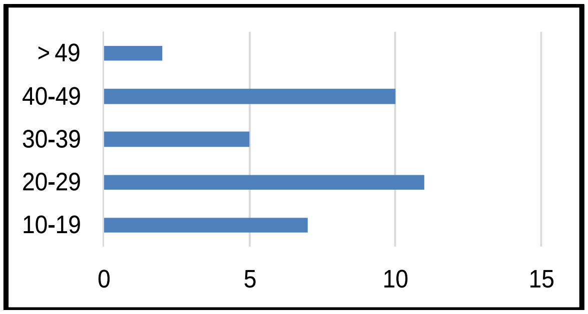

Figure 4.3: number of patients according to size of meningioma

Types of meningioma and necrosis:

According to the necrosis appeared 6 months post gamma knife. High percentage of necrosis appeared when the meningioma were non basal (76.5%) than with basal meningioma (44.4%) as shown in fig (5).

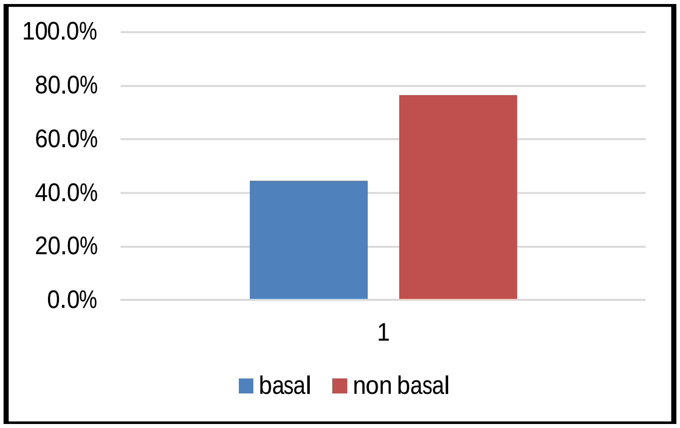

Figure 4.4: Types of meningioma and necrosis:

Dose of radiation and associated necrosis:

According to the effect of dose and necrosis appearance six months post gamma knife, it appeared that necrosis were 100% appeared when the dose 18 grey and above , 75% when the dose 14-16 grey, and only 15.4% when the dose 10-12 grey as shown in figure (6).

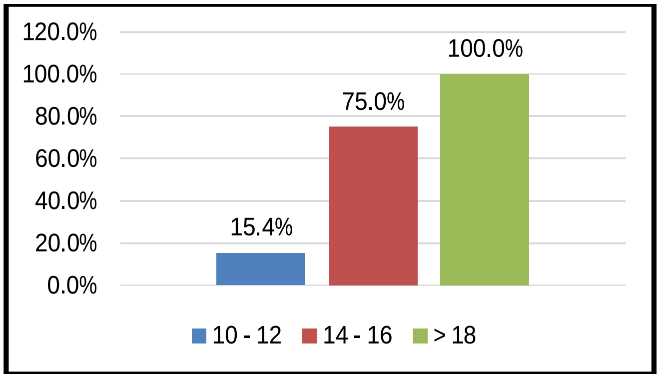

Figure 4.5 : dose of radiation and associated necrosis.

Type of meningioma and associated edema:

According to the development of edema associated with specific type of meningioma 6 months post gamma knife, we found that 47.1% of non-basal meningioma developed edema while only 38.9% of basal meningioma developed cytotoxic edema as shown in figure (7).

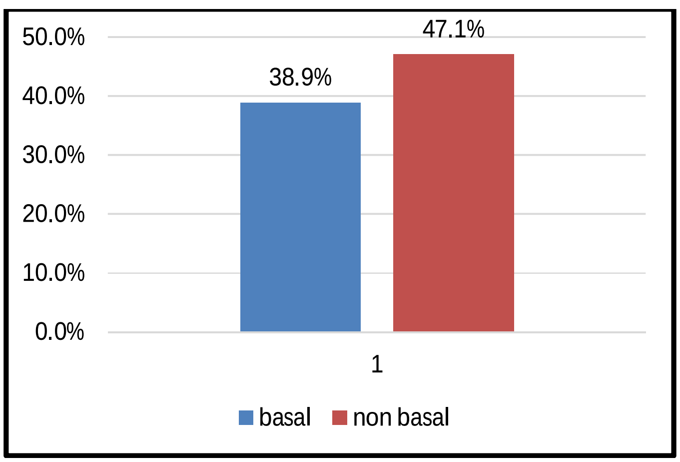

Figure 4.6 : type of meningioma and associated odema

Radiation dose and associated edema:

According to the relation of dose in grey used in gamma knife and associated edema, 60% of patients developed significant edema when dose (18-24) grey, 41.7% % when the dose was (14-16) grey and 30.8% when the dose was (10-12) grey as showed in fig (8).

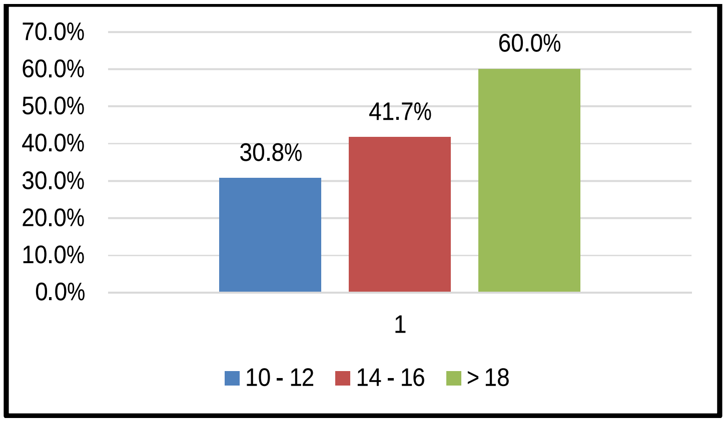

Figure 4.7 : dose of radiation and associated edema

Headache:

According to the relation of headache 6 months post gamma knife with the number of patients, it appeared that headache relieved in 24 of 35 patients as shown in figure (9).

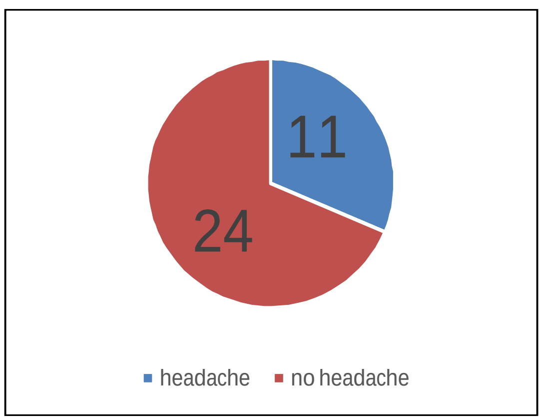

Figure 4.8 : Headache after gamma knife surgery.

Mortality rate and complications:

The mortality rate is 0 and there was no complications reported in our study.

DISCUSSION:

Meningioma is the commonest benign primary brain tumor in adults with peak incidence at 45 years, and it is widely common presented in neurosurgical practice.

In this study, we tried to evaluate the 6 months effectiveness of gamma knife in meningioma.

Age distribution:

The majority of the patients treated by gamma knife in our study is between (40-49) year old. This is representing the common incidence of meningioma in this age group; the incidence of meningioma is peaked in 45 years.[7]

Specific location of meningioma:

Specific types of meningioma in my study was higher in convexity and parasagittal (17.1% for each). This looks near the percentage of the study stated in Youman's Neurological surgery which was 35% for convexity and 20% for parasagittal meningiomas, respectively.[20]

Size of meningioma:

The majority of meningioma in my study that were treated by gamma knife was between 20-29 mm, followed by 40-49 mm (11,10 cases respectively). The lowest number was in > 49 mm. In our study meningioma less than 40 mm was higher than more than 40 mm (23 and 12 respectively). This reflect the higher tendency to operate this large meningioma by surgery and use the gamma knife for smaller tumors. According to Steven J. DiBiase median tumor volume was 44 mm .[21]

Types of meningioma and necrosis:

The necrosis after gamma knife surgery for meningioma was higher in non-basal meningioma than basal meningioma (76.5% and 44.4% respectively). This may due to higher radiation dose used in treatment of non-basal meningioma and conservative trend by using lower radiation doses used in basal meningioma avoiding radiosensitive neurological structures in the base of skull.

Dose of radiation and associated necrosis:

Necrosis appeared 100% when using > 18 Grey. The necrosis is decreased when using lower doses 14-16 Grey and 10-12 Grey (75% and 15.4% respectively). This reflects the high incidence of necrosis associated with increase dose of radiation as a general concept of radiation effect of tumor cells.

Type of meningioma and associated edema:

The higher percentage of edema appear in non-basal meningioma compared with basal meningioma (47.1% and 38.9% respectively) this due to higher radiation doses used in non-basal meningioma which causes more changes at the cellular level.

In a study of Jason P. Sheehan, development of peritumor edema were 40% in parasagittal and falx meningioma.[23]

Dose of radiation and edema:

Higher doses of radiation associated with higher percentage of edema, this reflect the effect of radiation which cause direct cell injury.

According to Sang Ryul Lee , radiation induced edema was highest when max dose > 24 grey and with preexisting edema.[23]

Headache:

Gamma knife surgery improve headache in our study. 68.6% of patients where free of headache after 6 months post gamma knife and that explained by fibrosis of dural nerve ending by gamma knife irradiation that previously irritated by meningioma infiltration of the dura, while the rest of patients that did not improved because the cause of headache is due to raised intracranial pressure.

There were no new neurological deficit reported post gamma knife and the mortality rate was 0, in Steven J. DiBiase , neurological deficit observed in 8.3% and mortality were 0.[21]

Conclusion

- Gamma knife is good and safe procedure in treatment of meningioma when indicated especially when surgery carries high morbidity and mortality.
- The peak incidence of meningioma is in the fourth decade with female predominance. The majority of meningioma is convexity and parasagittal.
- Surgical option is more viable in the large meningioma while gamma knife is mostly used in smaller tumors.
- The non-basal type of meningioma has better short time response to gamma knife (better response in convexity and parasagittal), while in basal type there is decrease response to gamma knife in comparison to non-basal meningioma.
- The necrosis and edema is dose related; higher dose of radiation is associated with more necrosis and edema.

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