Gamma Bulletin

A Newsletter from the Gamma Knife Center, Cairo

Volume 1 No 1 January 2002

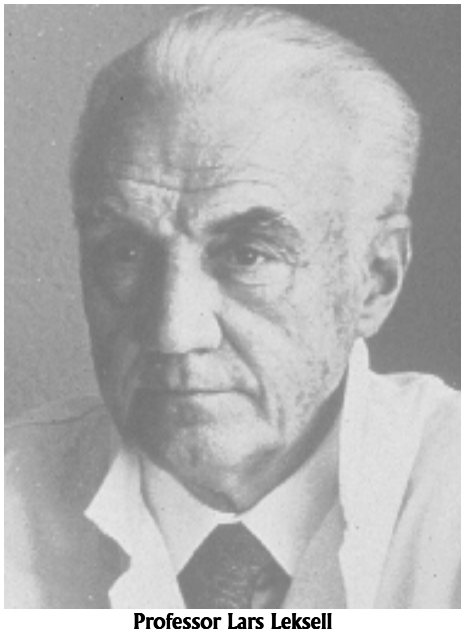
New Method at Nasser Institute

The Nasser Institute is the first Institution in Africa to acquire a **Leksell Gamma Knife**. The machine started work officially in August 2001. However, preparatory work has been going on for long before this and patients have already been treated with the new method. To many people the nature and purpose of this machine is not at all clear.

So the first issue of the bulletin is devoted to explaining a little about Gamma Knife radiosurgery and what the Gamma Knife Center, Cairo is doing in this field.

Radiosurgery

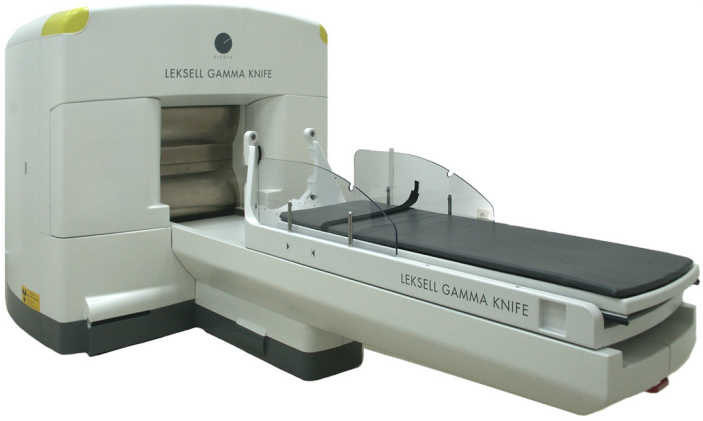
Radiosurgery was invented by a Swedish Professor of Neurosurgery in 1951. It was he who first used the word radiosurgery. Dr. Leksell had had a more than usually detailed education in how the nervous system worked and he thought that many operations did not show the brain the respect due to such a complicated and delicate tissue. So he dedicated his life to developing more delicate methods. The idea behind radiosurgery was that it was more elegant to perform an operation without opening the head. After much preliminary research Professor Leksell settled on Gamma Rays as the best instrument for performing this kind of surgery.



Professor Lars Leksell

What are Gamma Rays

Two kinds of electromagnetic rays are commonly used in medicine. These are X-rays and Gamma Rays. The rays as



Model 'C'' Gamma Knife

rays are very similar. Where they differ is how they are made. X –rays are made in a man made machine and Gamma Rays are produced by the breakdown of a radioactive substance (or isotope). As Dr. Leskell's machine uses Gamma Rays it is a Gamma machine.

Why Gamma Knife

The definition Dr. Leksell gave to radiosurgery was a single session radiation treatment where radiation is delivered with surgical precision. Surgery is carried out with a knife. Since his machine uses Gamma rays it was a simple extra step to call it the Gamma Knife. As the reader can see this 19 ton machine does not look at all like a knife. But it is the machine's function not its appearance, which justifies the use of the term.

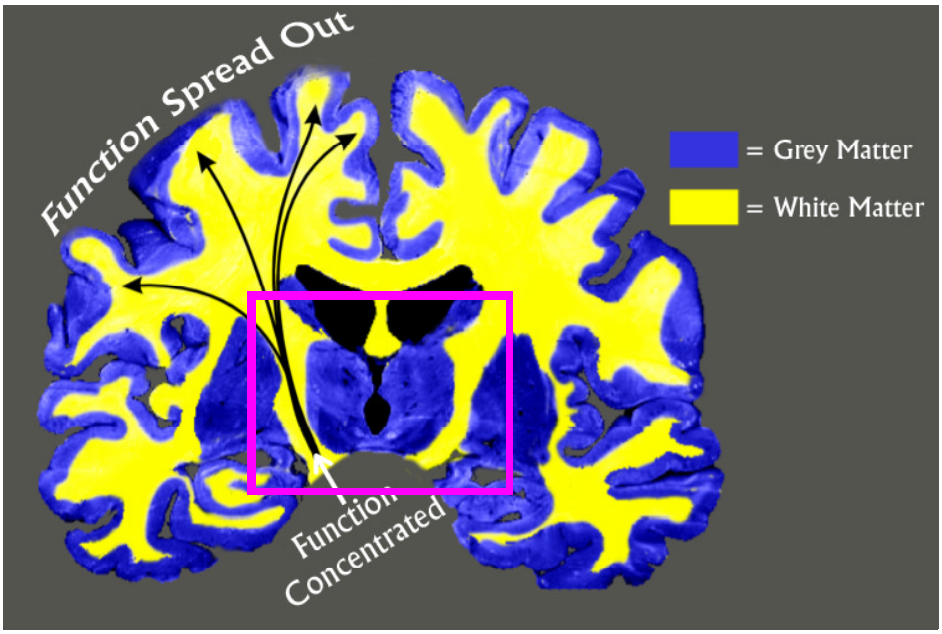
What is it for

Today neurosurgery is very much safer than it was even 20 years ago. Better anaesthesia and the improved lighting and view of the operation gained by using an operating microscope have been major contributions to this increased safety. Even so the brain remains a major challenge for the surgeon. There are still areas where he does not want to go. The places inside the brain where there is most risk are the deep central portions. In addition the skull base or part of the skull the brain sits on is also a hazardous area.

Danger Areas

There are reasons that these two areas are particularly risky. The central part of the brain can be reached with accuracy today so it is not just the depth that is the problem. The difficulties are rather related to the way in which the brain is constructed. It is a reasonable analogy to suggest that the surface of the brain is like a computer while the deeper portions are like the wires. The computer may be more complex in its nature but its components are spread

out so that a small amount of damage may pass unnoticed. The central wiring is very compressed so that the wires (nerves) to many parts of the body are all compressed together in a tight space. This means that even a slight damage may have very marked effects on the patient. Thus the centre of the brain is a risky area for the surgeon. (See the diagrams to the right and below). The skull base is risky because it is hard to access parts of it. However, the major difficulties are related to the nerves and blood vessels, which enter and leave the skull through its base. Damage to these will give the patient long lasting significant losses of function.



This diagram shows how the nerve fibres are arranged in the brain. The grey matter (blue in this diagram) is like the brain's computer. The white matter (yellow in this diagram) is the brain's wiring. As the diagram shows the wiring is spread out on the surface but concentrated in the deep parts of the brain. Thus while the white matter is not so complicated as the grey matter, damage in the central can affect far more function than damage on the surface. This means the patient will suffer far more paralysis.

When a patient has a stroke it is damage to this deep white matter which causes most of the trouble.

Thus, the deep central regions are not places where surgery can be safe because so much function is concentrated in such a small space.

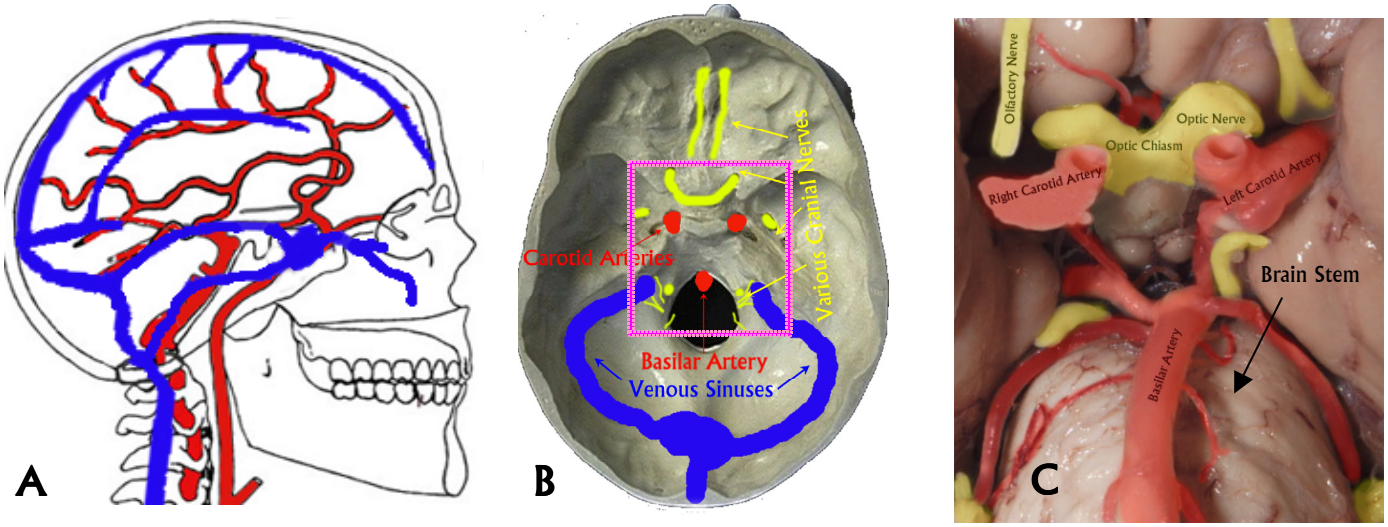
The black arrows indicate individual nerve fibres to illustrate the relationships

The lilac rectangle outlines the area which neurosurgeons prefer to avoid.

Today!

While modern skull base surgery is a well-developed and skilful technique there are still many diseases, which cannot be completely treated because of the risks.

The risks of operating in the centre of the brain and underneath it at the skull base are major reasons for the value of radiosurgery. This method avoids



[A] Is a diagram of the arrangement of the arteries and veins in the head. It is clear that they enter and leave through the skull base.

[B] Is a diagram of the skull base showing where the red arteries blue veins and yellow nerves leave the skull. These are firmly since they pass through the bone and are often in the surgeon's way. Damage to them can produce profound damage to the patient's function. **In this picture you are looking from above down**

[C] This is an enhanced picture of the base of the brain. **In this picture you are looking from below up**. Arteries and nerves are shown. The brain stem contains the continuation of the fibres running to and from the brain in addition to collections of nerves for controlling the feeling and movement in the head. The picture shows how close everything is to everything else. Thus there is very little room for error. The tiny blood vessels visible branching from the basilar artery are each and every one of them vital. Damage to just one could give massive loss of function.

The dotted lilac rectangle again indicates the regions where the dangers of surgery are greatest. Thus this diagram illustrates why the skull base is also an area where open surgery can be more hazardous because of the way the body is made. The possibilities today are much greater than 20 years ago but there are still definite limitations to what may be achieved with safety. Thus, a most important role of **Gamma Knife radiosurgery** is to take over where the surgeon does not want his knife to go. The technique helps the surgeon and increases the chances of safe effective treatment.

manipulating sensitive central parts of the brain or blood vessels and nerves leaving it are under surface. Thus, radiosurgery permits safer surgery allowing the surgeon to stop operating before he gets into a really risky situation. Radiosurgery can treat the part of the tumour or other disease process, which remain after surgery.

What has it achieved?

The early days

In the first years Professor Leksell was very cautious and scientific in his approach. Only a few patients were treated as the method gradually proved itself in the treatment of living people.

The watershed.

After many years in Stockholm, a couple of units were placed in departments run by ex pupils of Leksell. One was in Buenos Aires and one in Sheffield. Then the Unit in Pittsburgh started operations in 1986 and the milieu changed quickly.

The Pittsburgh group treated many patients and reported results with great clarity and honesty. Anyone could relate to what they were doing. And to be honest the location of Pittsburgh in the USA was important in spreading the use of radiosurgery.

Now Routine

Today the situation is very different. It is almost impossible to hard to open a major professional journal on neurosurgery without finding an article devoted to some aspect of radiosurgery.

Moreover today more than **150000** patients have been treated with the method.

Gamma Knife Center, Cairo The Background

There have been great advances in the design and applications of the Leksell Gamma Knife since the first prototype was used in 1967. The understanding of many of the relevant diseases has changed and new ways of assessing treatment results have arisen. Perhaps one of the most dramatic changes in the field has been the increasingly comprehensive computerisation of the necessary imaging techniques. In hand with this an increasingly sophisticated dose-planning system has been developed. Recently, automation of the treatment process has also been introduced in recent years.

This constant flow of research and development involves the employment of a highly skilled and creative technical staff and to meet modern standards all changes must pass through an exhaustive set of checks before they will be accepted by national licensing authorities. All of this costs a lot of money apart from the cost of the actual Gamma Knife machine itself.

The result is that this equipment represents a major cost for any hospital. Moreover, in addition the machine has to be housed in an appropriate building and facilities for the necessary minor procedures must be present as well as waiting areas, refreshments and places for conferences, discussions and patient assessment. Thus the financial burden is heavy for acquiring such equipment in almost any country. Yet since radiosurgery is now a standard method, health authorities are increasingly under pressure to make it available to their peoples.

The way this has been solved for the Gamma Knife Center Cairo is by using the BOT (Build Operate Transfer) system. The machine is installed through the medium of a company consisting of foreign and local investors. People already expert are brought in to operate it for a period and after a while the ownership will pass to the Ministry of Health and Population under the administration of the Nasser Institute. At present a Swedish company, Scandinavian Care Radiosurgery, which is a subdivision of a larger organisation called Scandinavian Care AB, Stockholm, manages the Gamma Knife Cairo.

Details about Scandinavian Care AB can be found at:

http://www.scandinaviancare.se/staff.html.

What makes the company special is the collection of multiple focussed expertises under one roof. This includes the following:

The development of techniques and methods aimed at changing the delivery of health care within a region and/or in a health care facility in order to achieve maximum benefit with a minimum of resource consumption.

In-house competence within various fields, such as medicine, medical planning, management, economics, logistics and architectural engineering are necessary.

A network of individuals and companies with cutting edge competence in various areas such as:

- Architecture
- Project management
- Medical equipment
- Construction contracting
- IT
- Information and PR
- Financing
- Export of health care services

Day of the Gamma Knife Patient

Most people are anxious about illnesses in the head or brain. This is particularly true if the person is told they need an operation. While Gamma Knife Radiosurgery does not involve opening the head as in conventional neurosurgery, it is still a major procedure and an understandable cause of anxiety to patients. Also it uses radiation, which makes everyone worry about cancer, even though the majority of Gamma Knife patients do not have this diagnosis. Thus what follows is a short account of a day in the life of a Gamma Knife patient. IT tells you what to expect on the day of treatment.

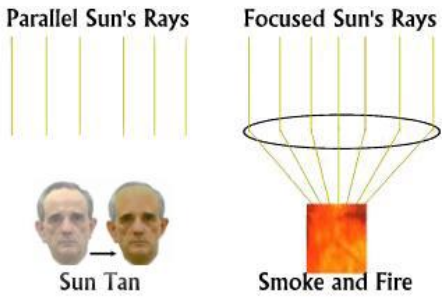
The nature of the method

How does the Gamma Knife work? It is surprising how many people still think that it is some kind of laser. While medically qualified readers need more detail and can find it in the specialist literature, the patient is not interested in such detail. Nonetheless the patient needs to know the principle.

It is useful to remind people of the way a magnifying glass focuses the sun's rays. If people lie out in the sun they get tanned but they do not burst into flames. However, if the sun's rays are focused it is easy to start a fire.

The Gamma Knife focuses radiation, which is powerful enough to kill living cells. This makes the effect much more powerful. At the same time the machine allows the doctor to sculpt the

radiation field to match the shape of the target being treated. Thus, the essence of the method is very accurately applied focused radiation. How much damage the rays do is determined by how long the patient is kept at the radiation focus. This is just like the magnifying glass which can discolour a piece of paper or make it burst into flames all according to how long it is kept at the focus of the sun's rays.



The safety of the method

To date it is believed that no-one has died from Gamma Knife radiosurgery. Some people have suffered from minor complications but these have decreased in number and severity with continuing improvements in imaging methods and treatment planning.

The disruption of the patient's life

In general the treatment takes one day out of the patient's life. In addition there will be a previous outpatient appointment and subsequent imaging studies. The actual treatment however is carried out as an outpatient procedure during one day. *The day of treatment*

The patient arrives at 8 o'clock and should fast from midnight unless they are diabetic. Diabetic patients should not change their diet or fast. The patient will arrive at the Center with those members of the family who are deemed suitable to assist and support

On arrival the patient will be taken to a room where a brief set of notes is taken and an examination is undertaken. The findings from this brief appraisal form the clinical base-line, which will be used to assess progress in the months and years to follow.

After the clinical examination is completed the patient is taken to the frame application room and the frame is applied. This is a metal 'crown' which is fixed to the head with four pins, which are screwed to the bone. The frame is made of aluminium and is quite light and is not uncomfortable to wear. However, the application does require 4 injections of local anaesthetic, two to the forehead and two to the back of the head. These sting a little. If a little time is taken the actual screwing in of the pin is painless. However, the frame has to be applied tightly and some pressure is felt. Patients react very differently to this. However, all seem to agree that the feeling of pressure becomes tolerable after 5 to 10 minutes.

Once the frame is applied the next stage is to take the images. These are usually MRI images today. It is necessary to check the accuracy of the MRI machine with each examination. The patient is placed in the MRI and the images are taken after an injection of MRI contrast material (gadolinium). The MRI is painless though for some patients the position in which they lie can be a bit awkward. The procedure seldom takes more than 15 to 20 minutes.

After the MRI is over the patient must settle down to a long wait. The doctors will be introducing the images into the computers and then start planning the treatment. This can take a few minutes but it is not unusual for planning to take an hour or two. The patient is welcome to have drinks during this period.

When the treatment planning is finally completed the patient will be taken to the Gamma Knife room and attached to the Gamma Knife. He/She will then be drawn in and out of the machine several times. This can take time and is not a very interesting experience. In fact after the images are taken the patients have a fairly boring day.

Once the treatment is complete the frame is removed and the head is bandaged overnight, in case there is any oozing of blood from the places where the pins pierced the skin. The treatment is now over and the patient may return home. The next follow up will be at 3 to 6 months depending on the nature of the disease. Most follow up is with MRI.

There is one variation to the routine described above and that is in the case of children who may well require a general anaesthetic. This means they will stay overnight in hospital following the treatment.

The following short tale is the best way to illustrate how easy it is to tolerate Gamma Knife Radiosurgery, which is a true out-patient procedure for adults. There was a man treated in Stockholm in the morning and in the afternoon he chaired the board of his company.

The picture shown here is from a patient treated in Cairo in fact the first patient treated at the Gamma Knife Center Cairo. She has graciously allowed us to use this picture. As the reader can see, she is coping with her treatment day without any major problem.

People at the Gamma Knife Center

One of the directors of Scandinavian Care AB, Stockholm, who is responsible for the Gamma Knife Cairo Project is PO Juhlin. Mr. Juhlin or PO as we call him is an economist by training. He brings the benefits of his organisation over the phone and on his visits to the Center where he initiates discussions about strategy and efficiency and helps with local administrative issues with advice or by putting us in contact with the appropriate people. It is a form of management, which delegates where appropriate while supplying support where necessary. It is very comfortable way of working.

The CEO of the Gamma Knife Center SAE, the company that owns the Gamma Knife Center Cairo is Moustafa El-Asmar. Moustafa is an experienced Cairo businessman who has experience in such diverse areas as the aircraft industry and the Health sector. He also speaks fluent Swedish.

At the centre there are various members of staff some of whom live in Cairo and some of whom visit. They have various tasks to perform and the daily organisation is the responsibility of two people. However, all members of the staff have vital functions to perform and have quickly become involved in the centre's activities and are taking pride in their work.

The major areas of responsibility of the Center are clinical and administrative. The allocation of the work within these areas posts falls two to two people.

Management Team

The administrative work is undertaken by Dr. Amr Rifaat. Dr. Rifaat has had a varied career. He has a doctorate of engineering from Sweden and he has been involved for many years in helping people in Egypt gain access to appropriate health care. He has also been a teacher. He also speaks fluent Swedish. Thus he is well qualified for a post involving co-operation between Egypt and Sweden. In addition to the above he has professional experience from the construction industry, which ensures that the building work of the Gamma Knife Center is of a high standard.

The Clinical work is the responsibility of Dr. Jeremy Ganz. He is a British Swede having spent most of his life as a neurosurgeon in Norway. He speaks fluent Norwegian and since Swedish is very similar to Norwegian he is understood by Swedes who are concentrating on what he says. He has directed a Gamma Knife in Norway and has travelled the world teaching people how to start up Gamma Knife radiosurgery sites. He has also written an introductory book about the Gamma Knife.

The Center is also fortunate to have the services of two expert nurses from Stockholm. Kristina Hautenen has been nursing with the Gamma Knife since the time of Lars Leksell whom she has assisted. She is the most experienced Gamma Knife nurse in the world. The Cairo center is very lucky to have obtained her services. In addition there is Lena Ahliny who also helps to train the nurses locally. Lena comes from the west coast of Sweden, far from Stockholm. She is an experienced operating room nurse and has also been engaged in activities for many years to better the conditions of nurses and to improve the quality of nursing.

The first person whom the visitor to the Center will meet is probably Dr. Mohammed. He is responsible for our administration and he mans the telephone and keeps the paperwork and images in order. Dr. Mohammed has a medical qualification and a most useful interest in computer science which is very helpful when it comes to organising our administration. Dr. Mohammed's desk is placed facing the main door and he is ever ready to greet new visitors.

The physical maintenance of the building and its everyday running is in the hands of Atif. His cheerful face bobs everywhere where practical problems

Local Administrative Staff

arise and helps to solve them quickly and efficiently. It may be an uneven floor, a missing pipe, a broken fuse or an invasion by ants. It is no matter. Atif will know the answer and apply it.

Another most important member of our team is Mohamed the driver, Cairo traffic is a place for specialists and Mohamed is certainly that, whether he is driving staff or patients from one location to another in the busy crowded noisy streets.

So this is the team of people who are responsible for the day to day running of the Gamma Knife Center in Cairo. However, there are other people who are intimately involved in the project. Many local doctors refer their patients without whom the center would have no reason for existence. In addition to these referring doctors there are in particular two doctors who have received special training in Stockholm and are undertaking the Center's course in Gamma Knife management.

These are Dr. Wael Abdel Halim Reda a neurosurgeon and Dr. Khaled an oncologist. Finally the center uses the services of Mr. Magdi Hafiz and Mr. Hosam Alhamamsy both of whom are experienced medical physicists and who are currently undergoing the Center's course in Gamma Knife treatment planning. Gamma Knife radiosurgery involves methods and principles which differ in some ways from conventional

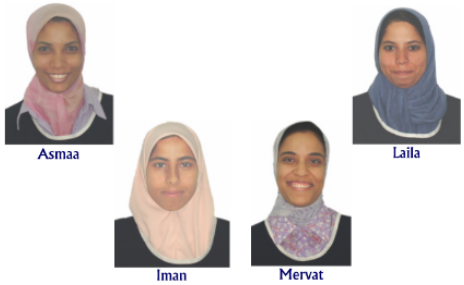
Local Medical & Physics Staff

radiotherapy, but as with any treatment involving radiation a physicist is needed to guide the treatment.

Apart from the visiting nurses from Sweden, Kristina and Lena, the Center also needs local nurses to carry on the nursing tasks in the long term.

A little group of nurses has already been assembled and regularly help with treatment and the out patient clinic.

Local Nursing Staff



These ladies are skilled and well trained in general nursing procedures and have great promise as specialist radiosurgery nurses.

The Gamma Knife Center Building

The Gamma Knife Center in Cairo is very lucky. The Center is large for a Gamma Knife unit with spacious work rooms and offices and a pleasant cool and well lit milieu. Some of the pictures which follow give an idea of the feel of the building itself.

The exterior is covered in white stucco.

In the front is a pleasant garden which contains the floral initials of the center.

There is also a young palm tree set in a rich green lawn.

The light shafts are very much a feature of the design. The interior of the building is cool but is lit by natural light caught by the light shafts giving a natural feeling while indoors.

The main entry space contains a waiting area which is lit by a light shaft.

The effect of the light shaft is illustrated by the above picture of one of the corridors.

A rest or waiting area is strategically placed to catch the light in this internal corridor.

The room where the patient will sit with family while awaiting the next stage of the procedure is a little darker which is more comfortable and restful.

Every attempt has been made to ensure that the patient's visit together with family will be as comfortable as possible. One of the details to ensure this is to request that patients bring CDs of their own choosing. These can be played during treatment since the Gamma Knife is deliberately designed to permit this.

The Open Center

The Gamma Knife Center in Cairo is an 'open' center. This means that it is open to any appropriately qualified physician to bring his patients here and treat them. Anyone wishing to be granted this freedom must first fulfil the Center's training requirements which are modelled on training institutions abroad. The point is that all are welcome. Apart from the possibility of treating patients, all colleagues are invited to visit us and see what we do. In this way the whole concept of radiosurgery becomes more real and it is hoped that this open approach will help to spread knowledge of radiosurgery in Egypt and the Middle East as it has done in other parts of the world.

The C Model Gamma Knife

The Gamma Knife Center in Cairo has acquired the very latest model of the Gamma Knife. This includes an important new technology.

All previous models have relied on the physician responsible to make sure the patient goes in and out of the machine as is wished. This method works well but is time consuming and could be a source of inaccuracy if the physician is not extra careful. Many Gamma Knives in other countries, even in the most famous centres still use this method.
The C Model moves the patient in the Gamma Knife automatically. It checks that all the positions the patient must reach are achievable and it does this to an improved accuracy not previously available. No error of more than half a mm is possible because the system will refuse to continue. Thus Cairo is lucky to have this latest machine with these features which are not available for any other radiosurgery method.
This ends the short introduction to our center. The rest of this bulletin covers the diseases more commonly treated in the Leksell Gamma Knife.

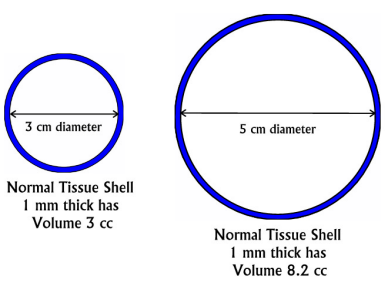
Gamma Knife Treatment: Some Issues

Target Volume

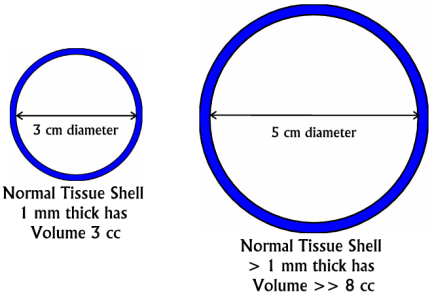
Radiosurgery works best for small targets. This is not a feature of the Gamma Knife as such but applies to all radiosurgery methods. There are two reasons based on simple geometry.
Firstly, the aim is to deposit a large dose in the target with a rapid fall off of radiation outside the target. This means that the dose fall outside the target must be steep.
Secondly, all instruments which deliver focused radiation suffer from the same problem. Bigger targets are associated with a less steep fall of radiation outside the target than smaller targets. For this biological reason smaller targets are to be preferred.
The diagram below shows the effect of volume on dose fall outside the target and the increased risk to normal tissue with larger volume targets.

Radiosurgery and Microsurgery

Thus radiosurgery is preferred for smaller lesions. These may be either small at presentation or may be residual tumour after surgery. The radiosurgery thus helps the surgeon to achieve safer surgery by avoiding dangerous regions. At the same time the neurosurgeon helps the radiosurgery by reducing the target volume permitting a safer and more efficient radiosurgery treatment.
The diseases treated by radiosurgery fall roughly into three main categories; tumours, vascular diseases and functional indications.



If the diameter of a sphere is increased but not doubled as in this diagram. The volume of a mm thick shell outside the sphere increases by over 2.5 times. Since the size of normal cells is the same in both cases the number of normal cells at risk for damaging normal cells greatly increases because so many more cells receive the high dose.



The volume of a shell outside the target containing the same dose as a mm shell round a smaller target is thicker than with the smaller target because the dose fall is less steep. Thus the number of normal cells at risk is even more than would be predicted on basis of the increase in volume alone.

Tumours are today by far the commonest indications. Radiosurgery is not however used indiscriminately for any tumour in the head or brain. This is not just a matter of size as described in the preceding paragraphs. In some cases a reduction of intracranial pressure is vital, so some tumour tissue may need to be resected or a shunt may need to be inserted. In other situations local pressure will need to be reduced. This is particularly true for tumours which distort the visual pathways, where decompression of these pathways is the first priority. Radiosurgery does not act quickly. When speed is necessary surgery is to be preferred. Thus the choice of treatment is determined individually for each case and may be watch and wait, open surgery, radiosurgery or any combination of these treatment modalities. In some instances with larger tumours or targets with unclear limitations, fractionated radiotherapy will be preferred.

What is a good result?

The effects of radiosurgery may take a lot of time to show themselves. In the case of blood vessel lesions like arteriovenous malformations it may take 1to 3 years for the lesion to disappear. In the case of cavernous haemangiomas, the other common vascular indication there is really no way of knowing if the treatment is successful or not. Only time and more research will determine this.

For benign tumours it may take many years before the tumour shrinks. This is because of the way radiation kills cells. This is not an immediate death. The definition of radiation induced cell death is that the killed cell loses the ability to divide indefinitely. For convenience indefinitely is defined as 6 divisions. With benign intracranial tumours the rate of cell division is very slow. Thus, it may take months or even years before a fall in volume is detectable. Thus, no change in volume is accepted as a success so long as no subsequent growth occurs and provided the patient is followed up carefully. Indeed, it is now know that acoustic schwannomas have a tendency to swell in the first few months after treatment before settling down to shrink. This swelling is no cause for further action provided the patient suffers no clinical deterioration.

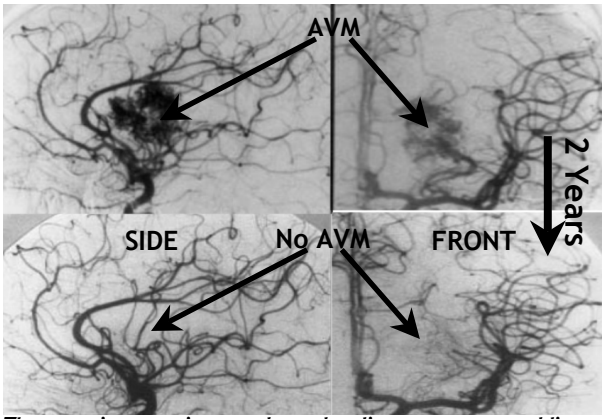
Gamma Knife Treatment: Indications

Vascular Indications

There are two main vascular lesions treated with Gamma Knife radiosurgery. One is the arteriovenous malformation or AVM and the other is the cavernous haemangioma. AVMs have been treated since the 1970s so there is a wide experience. Radiosurgery is mainly used for AVMs which are inaccessible to microsurgery and which have bled. The expected success rate is between 75 to 90% according to different authors. The definition of success is a normal angiogram. This is important. Angiography cannot yet be replaced with MRA which is not yet reliable enough. DSA is needed to define the lesion size to decide if radiosurgery is appropriate. It is needed at the time of treatment and it is needed to define that the AVM has been obliterated.

A good example is shown in the accompanying illustration.

The pictures below are taken approximately 2 years after the pictures above. The AVM is in a deep location, which as explained earlier prevents surgery. AVMs, which bleed, are a very dangerous illness and in cases such as this one radiosurgery is the only possible treatment today. Success is only accepted if the AVM has disappeared completely, which can only be determined by angiography.



These angiogram pictures show the disappearance or obliteration of the AVM after 2 years. This AVM was in a location where operation is too dangerous and not an option.

Tumour Indications

There are many tumour indications. These form the majority of the cases referred for Gamma Knife treatment.

Acoustic Neuroma

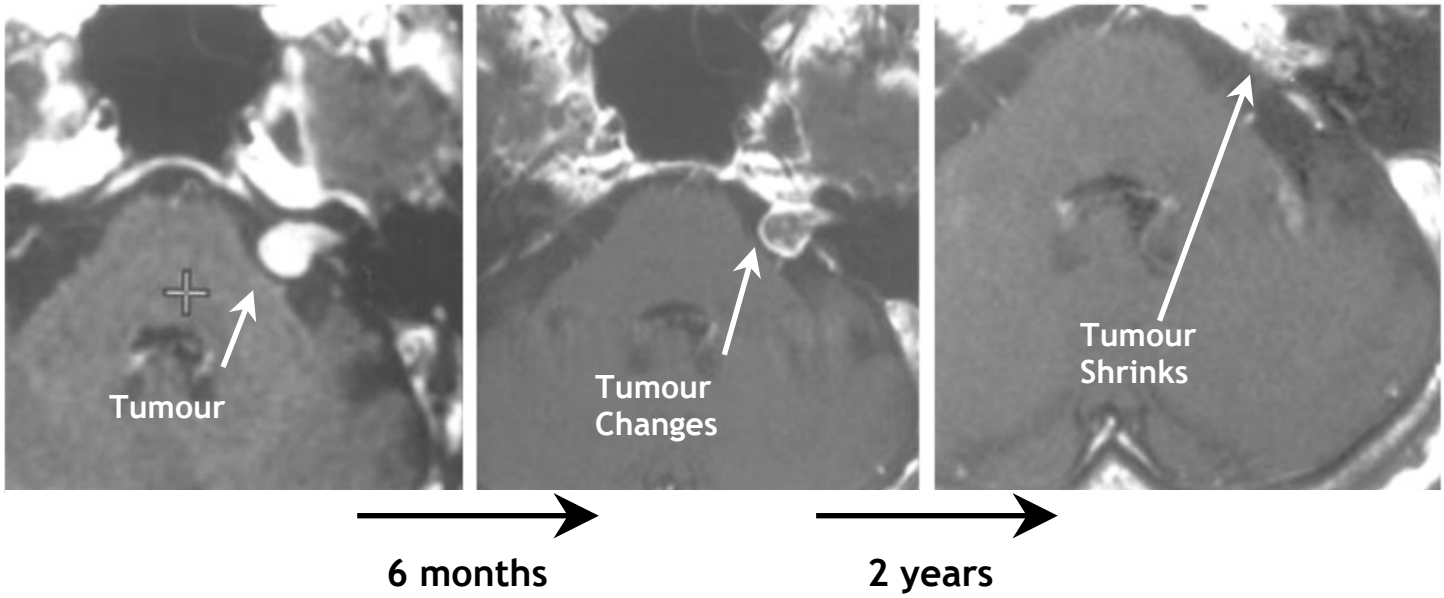
The tumour with which there is the longest experience has various names. It is called Acoustic Neuroma, Acoustic Schwannoma, and Acoustic Neurinoma. Its proper name is Vestibular Schwannoma but it will be called Acoustic Neuroma here to avoid confusion. This is a tumour which grows out of the cells which nourish nerve fibres. It usually starts in the internal acoustic canal deep in the skull. It is notorious for presenting a challenge to the surgeon, partly because of its close relationship to the facial nerve (which controls facial movement) and partly because of the important arteries, which are stuck to its surface. It is a tumour which may be treated by neurosurgeons or ENT surgeons. However, only experienced surgeons who operate a large number of these patients achieve consistent results. The main problem for the patient after surgery is the facial nerve, which may be damaged during the operation. This is particularly true for larger tumours. In the early days the tumours were only partially removed leaving part of the capsule, which contains them in place. This reduces the damage to the facial nerve but results in tumour recurrence. Today the Gamma Knife makes this once again an attractive policy since radiosurgery can remove what is left after the surgery of a larger tumour and it also enables the surgeon to avoid that part of the operation, which damages the facial nerve.

Loss of facial nerve function is a very great deformity for the patient to suffer and maintaining facial movement is a major concern today with this tumour. Before computer imaging techniques like CT and MRI the surgeon had no way of following up the tumour and there was a greater need to be radical at the time of surgery. However, now these techniques are available and radiosurgery can treat the remaining tumour after a more cautious operation the results of the treatment of these tumours can be expected to improve greatly.

In the case of smaller tumours Gamma Knife radiosurgery can to today claim to be the treatment of choice in most cases. Any operation on acoustic neuromas is a major disturbance in the life of the patient with two to three months off work. With radiosurgery the patient loses only a day.

The assessment of these tumours can be difficult. It is now known that a significant proportion of them swell a little after radiosurgery. However, so long as the patient suffers no clinical deterioration this swelling recedes and has usually disappeared after 9 to 12 months.

A good example of the course of an acoustic neuroma patient is shown below. Not all of these tumours reduce in volume this fast but the longer the period from treatment the greater the proportion of tumours that will shrink. The loss of contrast enhancement after a few months is commonly seen and is usually taken to be an indicator that a good result will be achieved.



Please note the following features. The tumour first shows a loss of contrast enhancement. This is often reversible and though often called radionecrosis there is no certainty about its nature. This change is widely believed to be a good indicator of tumour control. In this case the tumour shrinks faster than normal. The patient and surgeon should be prepared for a slight increase in tumour volume at 6 to 12 months. This is almost always temporary and should require no action so long as the patient does not suffer a clinical deterioration.

Today with modern dose planning it is thought that more than 90% of these tumours can be controlled with only a tiny fraction suffering any complications. These are usually in the form of a temporary facial movement loss, which will last a few months and only be slight.

Pituitary Adenoma

The pituitary gland hangs under the brain and is controlled by a tiny region of brain called the hypothalamus. The pituitary produces a number of hormones, which control the activity of other hormone producing glands within the body. A hormone is a sub-

stance, which is secreted. However, unlike sweat or spit it is not secreted down a tube to the exterior but is secreted directly into the blood. This gives the word endocrine to the glands, which make these hormones. Endo- means interior. The secretion is into the interior of the body in the blood. The group of endocrine glands are a self-regulating family, which are very important for the smooth running of the body's normal functions. These are the unconscious functions over which we have no control ranging from blood pressure to hunger. The pituitary gland directs their activities.

With such a complex job it is not surprising that the pituitary gland gives rise to not a single tumour but a complex group of tumours where radiosurgery has a specific role. It is an over simplification but it may be considered that these tumours present in one of 4 main ways.

Smaller tumours present themselves by producing a disease resulting from the over production of one of the pituitary hormones.

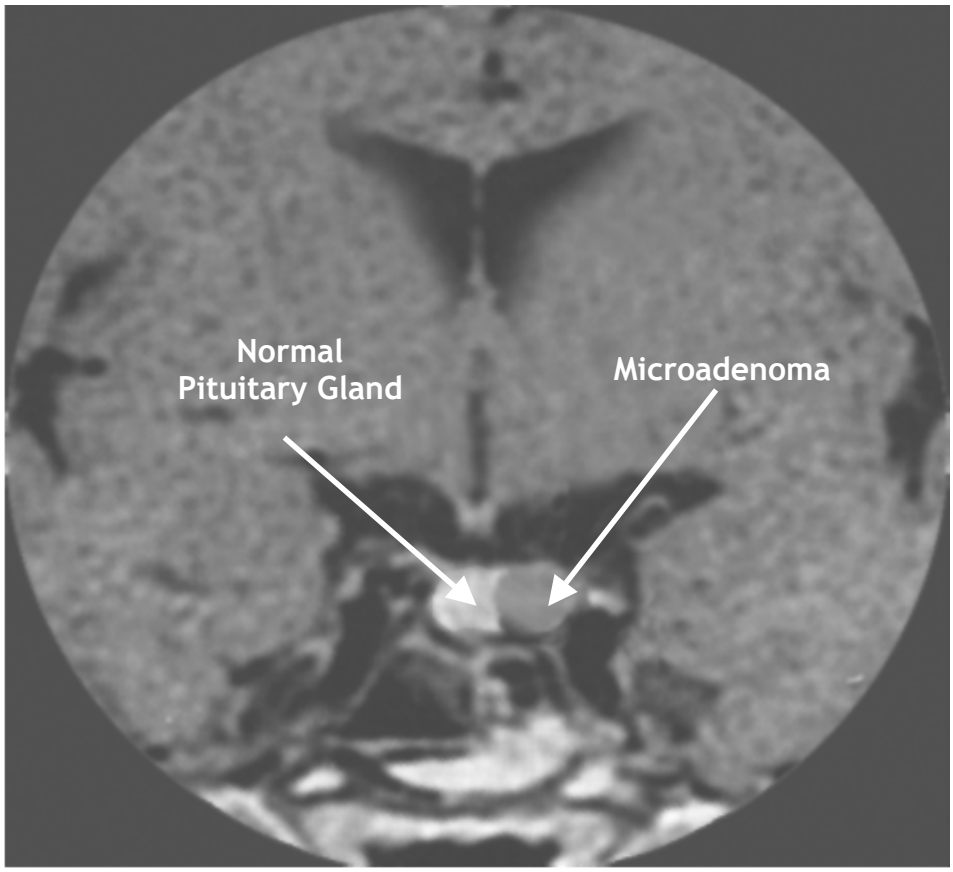
Larger tumours present by disturbing the vision of the patient, since they compress the visual pathways to which they lie adjacent.

Microadenoma

A microadenoma is defined as a tumour which has a maximum diameter of 10mm or less. These smaller tumours do not reach to the visual pathways and present due to a disturbance in hormone production, almost invariably due to an overproduction of some hormone. It is not necessary to go into detail about what happens in these conditions but there are three commoner varieties. There is over production of the hormone AdrenoCorticoTrophic Hormone or ACTH. This controls the production of cortisone from the adrenal glands, which are two small glands, whose name derives from the fact they are sitting on top of the kidneys (renal refers to kidney). Cortisone production is vital for proper body function and over production results in Cushing's Disease, which is a very dangerous condition. The second disease is from over production of Growth Hormone (GH), which as its name suggests is important in controlling the growth of the body. If this occurs in childhood the result is a giant. If it occurs in an adult, which is much commoner, then a characteristic change of appearance occurs with large hands feet jaws and ridges over the eyes. This is called acromegaly, which means big extremities. The appearance is not of itself dangerous but the disease is associated with heart damage, which is dangerous.

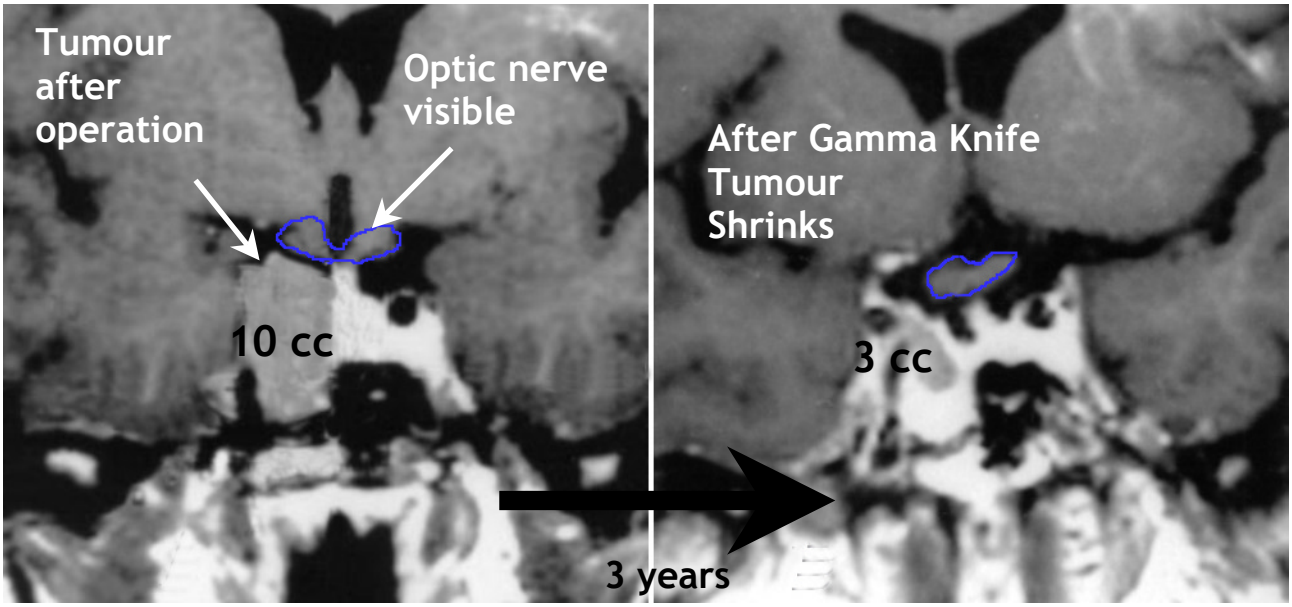
The third of the three conditions is due to an over production of a hormone called prolactin (PRL). Prolactin's normal function is to ensure secretion of milk for lactating women. Over production has however profound effects, with lack of menstruation and sterility being the most obvious.

The treatment of Cushing's disease and acromegaly is surgery and the treatment of over production of prolactin is medicine. However, these measures do not always work. This is where the Gamma Knife can help. Even



Patient with acromegaly after surgery. Only a Microadenoma remains. This is an excellent target for radiosurgery. The tumour is typically dark as it takes up contrast slowly. This patient was cured of her acromegaly after two years.

in the best hands about 20% of patients will require more than the standard treatment. Gamma Knife radiosurgery can be the extra method to use. However, while the tumour growth will be controlled it is much more difficult to control hormone overproduction. Nonetheless, a number of patients are cured who otherwise would remain threatened by what are dangerous diseases. At the present time it would seem that the Gamma Knife is the best back-up treatment for pituitary tumours where more conventional methods have failed.



This is a patient with an operated macroadenoma. Please note the following features. The tumour though large is a post-operative remnant lying in the cavernous sinus. This was a non-functioning adenoma so the only goal was to prevent growth. The visual pathways are clearly visible prior to treatment. If the visual pathways cannot be seen some other form of treatment should be attempted. The volume reduction was from 10 to 3 ccs. Note visual pathways outlined in blue.

It should be understood that it has been common for the results of radiation on small pituitary tumours to talk about reducing the amount of hormone production as if this was a successful treatment. It is not. The criterion for successful treatment is the same for radiation as for microsurgery. The hormones must be normalised. There is no evidence today that reducing hormone levels without normalising them has a significant benefit for the patient

Macroadenoma

It is a relatively simple matter to stop a pituitary tumour growing with radiosurgery. This is shown in the following picture. This is a largish tumour where further surgery was not possible. However, since the visual pathways are visible and only tumour growth needs to be controlled. This was possible. Please note that the original presentation of this patient was due to compression of the nerves of sight with visual disturbance and microsurgery was the necessary first step to decompress the visual pathways and thereby preserve or enhance visual function. Radiosurgery can never produce the urgent reduction in pressure that an open operation can. This is why radiosurgery is never used when urgent decompression is required. This can be decompression of the brain itself or some other specific intracranial structure like the optic nerves.

Meningioma

The brain is surrounded by three layers or sheets of cells. These are called the meninges. Tumours arising from these layers are called meningiomas. Since they arise from the brain's coverings a part of them will always be accessible from outside the brain. This makes them sound like easier tumours to operate. Nothing could be further than from the truth. However, it may be mentioned a minority are very simple to remove. But it is a small minority. The meningioma grows usually very slowly so the brain gets used to its presence. As a result the meningioma may achieve a very large size before the patient develops symptoms. Meningiomas grow round important structures so that nerves and vital blood vessels may be enclosed within their substance. They also have a tendency to be very hard and to bleed a lot. However, they tend to occur in fixed locations so that the different varieties are approached by a series of well defined operation approaches.

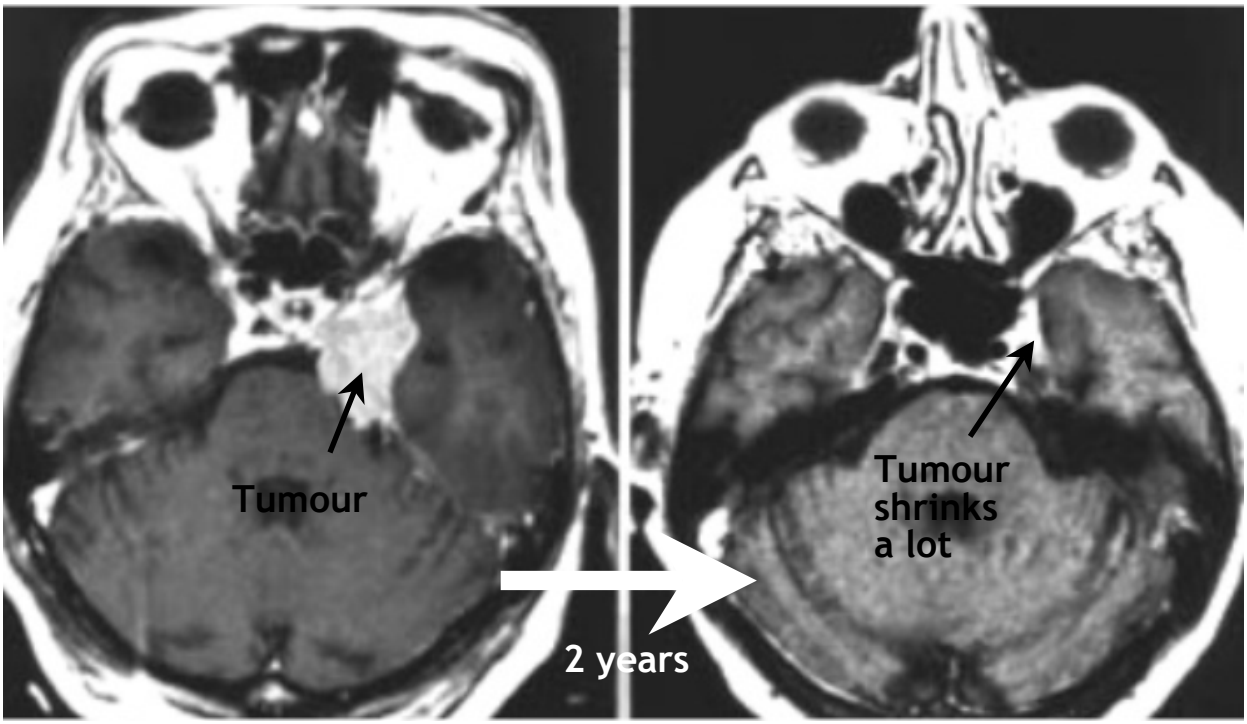
The trouble is that the price for removing a meningioma totally may often be an unacceptable quality of life. On the other hand failure to remove the tumour totally means that it will recur, even if the recurrence may take several years.

It is this characteristic which makes these tumours such good targets for Gamma Knife radiosurgery. While the presenting tumour may well be too large for radiosurgery the remnant after surgery will not be. Thus the surgeon may remove what is safe to remove and the Gamma Knife can destroy the remainder. This has led in the last ten years to meningiomas being one of the major indications for Gamma Knife radiosurgery with almost universally good results, provided the tumours treated are not too big.

Over the last few years it has become clear that the best meningiomas to treat are those at the base of the skull which involve nerves and blood vessels. On the other hand meningiomas which

are near to the top of the skull are best attacked with conventional surgery

using radiosurgery as a backup. It is true to say that most neurosurgeons are thankful for the introduction of from treatment of such tumours, because of the seriousness of their primary illness, there are still a great number who do benefit from this form of treatment. The treatment of brain the opinion of the oncologist are important factors in selecting this kind of patient for treatment. Here as elsewhere radiosurgery is a team effort. Not all tumours or patients are eligible



This parasellar tumour encases the carotid artery and the nerves on the way to the eye muscles. It is close to the optic nerve. These tumours are often hard and bleed copiously making them impossible targets for refined micro-dissection. Radiosurgery is a very useful solution as shown here. The period of two years is short for such shrinkage but over 90 to 95% of these tumours can be expected to stop growing and eventually shrink.

radiosurgery to assist them in the effective treatment of this dangerous disease.

The above picture is typical of the tumour which the surgeon lives behind. In what is called the cavernous sinus region it is intimately involved or surrounding important arteries, veins and nerves. This is a horrendously difficult if not impossible task for microsurgery. However, with radiosurgery about 75% of all meningiomas referred are in this region, just because it is so difficult.

Metastases

A metastasis means from another place and is the medical term for a secondary tumour, which has split off another tumour to settle away from the primary location origin. This is one of the two characteristics of a tumour which make it malignant or in other words a cancer.

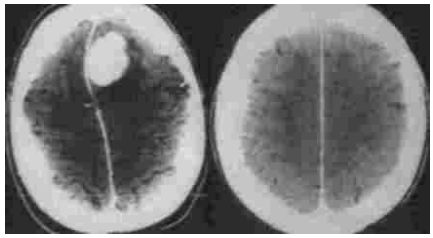
The brain is one of the locations where secondary tumours settle and this is the commonest form of brain tumour. While many patients will not benefit metastases has become one of the most popular indications for Gamma Knife radiosurgery in the last few years.

One of the advantages of this method of treatment is that it is possible to treat multiple tumours and multiple metastatic tumours are common.

Radiosurgery has been found to have two great advantages over conventional radiotherapy in the treatment of these tumours. Firstly, it is known that with conventional radiotherapy the result depends on the origin of the tumour. With radiosurgery the results are good no matter where the tumour comes from. Secondly, patients who have spread of tumours to the brain are very seriously ill and conventional radiotherapy is time consuming and keeps them away from their homes for up to 4 weeks and cannot be repeated if a subsequent tumour occurs. Radiosurgery is complete in a day and may be repeated as often as necessary if new tumours turn up later.

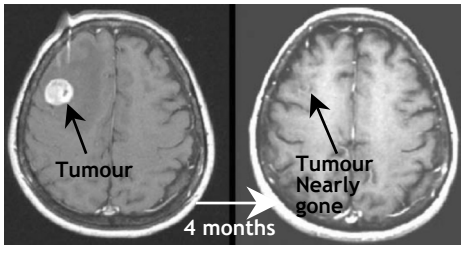
Nonetheless, the patient's general condition, the size of the tumour and and discussion between the different medical specialties is an absolute requirement when making a decision.

There is considerable swelling in the first picture, which resolves on treatment.

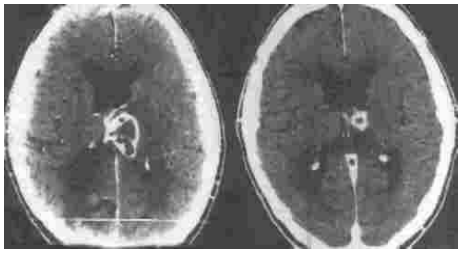


Single metastasis disappears after 3 months.

The second picture is less dramatic but just as effective.

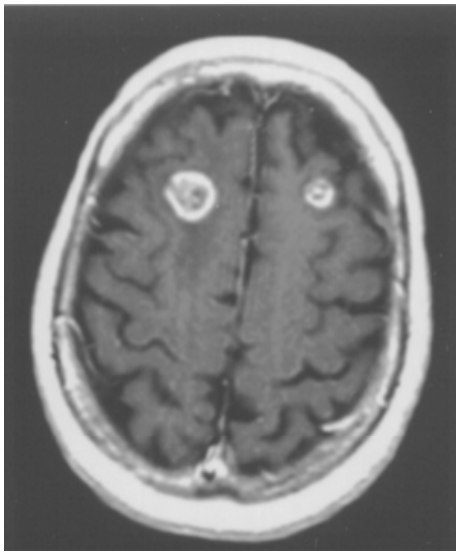


This third image shows a single metastasis which could not be treated with open microsurgery.



Central tumour efficiently controlled after 5 months.

The final metastasis image shows a case with multiple tumours. This was a simple matter to treat at a single session.



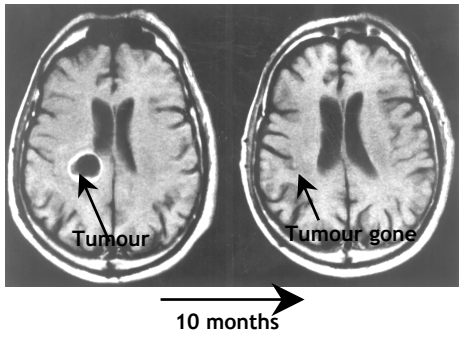
Gliomas

These are of course the primary brain tumours. This family of tumours is a less satisfactory group for treatment with radiosurgery. This is because many are highly malignant and because the edge is not properly defined on the images and because many are too large at presentation. In addition many low grade tumours are more infiltrative than expansive and normal brain and tumour are intermixed. Thus many low grade gliomas which are diffuse and most brain stem gliomas are not suitable for treatment with radiosurgery.

There are however some low grade gliomas which seem to do well. The pilocytic tumours of childhood seem to be well controlled though nobody has followed these cases long enough know for how long the treatment is effective. However, the first eight to ten years after treatment give reason to be cautiously hopeful. The lower grade tumours of other age groups can also be controlled at least for a while but this remains a still uncertain area. Mostly radiosurgery is used as a boost treatment.

The use of radiosurgery for glioblastomas is much less certain. Nobody has succeeded in controlling these tumours consistently. However, occasionally an improvement is seen. The general opinion is that the treatment may be used as an extra modality for patients referred by colleagues. It does not take the place of other treatments.

The following image is of a low-grade glioma in an adult which showed a remarkable regression over a short time. It is this sort of finding which encourages Gamma Knife users to continue to attempt the treatment of gliomas.



A Case where radiosurgery was helpful for a relatively inaccessible low-grade glioma

Functional Indications

The Gamma Knife may also be used for something quite different from treating illnesses which are visible on images. There are certain so-called functional diseases which may also b e treated with the method. Thus, some form of epilepsy, Parkinson's Disease other tremors and Trigeminal Neuralgia have all been treated with radiosurgery.

It is widely agreed that radiosurgery for Parkinson's disease is still the most difficult functional indication. Moreover the other tremors which have been treated are still too little reported for a definite view to exist as to the value of radiosurgery. So for this bulletin we shall consider two functional indications only. These are trigeminal neuralgia and epilepsy.

Trigeminal Neuralgia

This condition with severe lancitating facial pain, most commonly in the second and third divisions of the trigeminal nerve has become very popular for the Gamma Knife.

The treatment is extremely simple. One shot of radiation is given to a well known easily defined location. The dose is also now well known. The question is what is the advantage compared with other invasive methods.

It must be remembered the primary treatment of trigeminal neuralgia is tegretol up to a maximum of 800 mg per 24 hours. However, when this does not suppress the awful pain various interventions may be tried. The advantage of the Gamma Knife is that it is as successful as other interventions and has a lower incidence of treatment induced complications than any other of the methods currently in use. It is also much less painful than the other procedures performed under local anaesthesia and it obviously does not require a general anaesthetic as an open operation would.

Epilepsy

Epilepsy is also a condition in which tablets are the mainstay of treatment. However, sometimes the control is not adequate. The Gamma Knife is used in the same situations where surgery for epilepsy has proved useful. This means that the operations involve anatomical more than physiological localization of the epileptic region. The most effective region for brains without a tumour or AVM is radiosurgery of the temporal lobe.

Radiosurgery is useful is in reducing the frequency and intensity of epileptic fits associated with vascular anomalies and tumours provided an adequate dose is given.

Conclusion

The Gamma Knife is now in the Middle East and Africa. Gamma Knife radiosurgery is here for the service of the region and the GKC Cairo look forward to being able to help the many patients who may need this method.

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