

Introduction

This is a complex and technical topic and the subject of contention between clinicians. The aim of this fact sheet is therefore to attempt to define some of the terms commonly encountered and explain the differences in techniques. There is also a description of what a Gamma Knife treatment in Sheffield involves and the results which are achieved specifically in NF2. Commonly raised concerns about radiation treatments are then addressed.

Terms and definitions

Stereotactic radiosurgery and radiotherapy are minimally invasive ways of treating vestibular Schwannomas (VS, also called acoustic neuromas) with the aim of avoiding open surgical procedures. Stereotaxy means to touch or place in space and describes the use of a frame that is fixed to the patient's head and used as a guidance system. The patient, with the frame in place, is then scanned and this scan is used to generate a map with a grid system and precisely locate the tumour.

This map, which is of course specific for each individual patient, is used with the frame to target the radiation treatment, which is concentrated on the tumour, thus sparing the surrounding tissues. The radiation can be delivered as a single high dose treatment, which is called stereotactic radiosurgery. Alternatively the treatment can be fractionated, that is given as a course of multiple low dose treatments – called stereotactic radiotherapy. The techniques differ in a number of ways.

- A radiosurgical treatment is completed in a single day, and relies on the frame and precise targeting of the tumour to avoid damage to surrounding structures.
- A radiotherapy treatment is delivered over several days or even weeks, hence relocatable frames which can be taken on and off are used. Whilst this will increase positional errors, the fractionation, that is the use of multiple low dose treatments, may allow for recovery of the tissues between the individual doses being given.

Importantly, single dose radiosurgery and fractionated radiotherapy may have different biological effects on the tumour being treated. This can be likened to comparing a single hard hit with multiple light blows – the total energy imparted may be the same, but the response of the tissue may be very different. Hence 12Gy given as a single radiosurgical treatment will have a much more marked effect than six fractions of 2Gy given as a course of radiotherapy (Gray, abbreviated to Gy, is the unit used to prescribe and measure the absorbed dose of radiation). The radiation itself can be delivered either using a Gamma Knife or a linear accelerator (also called a LINAC).

- The Gamma Knife is a specialized machine that can only be used to treat conditions within the head. Gamma Knife treatments are almost invariably performed as single fraction radiosurgical treatments, and so the terms "Gamma Knife" and "stereotactic radiosurgery" have become to some extent synonymous.
- In the UK, LINACs are generally not only used for cranial work, and indeed may be used in part for general radiotherapy (treating cancers etc) and in part for stereotactic treatments. LINACs can be used either to deliver single fraction stereotactic radiosurgical or fractionated stereotactic radiotherapy treatments, although they are more associated with the latter.
- Reflecting the specialization of Gamma Knife units, the majority of stereotactic radiation treatments in the UK are performed with Gamma Knife rather than LINAC systems.

Gamma Knife treatment in Sheffield

Currently the Sheffield Unit treats more than 120 vestibular schwannomas every year.[1] Whilst the majority of these tumours are non-inherited unilateral or sporadic ones (rather than tumours secondary to NF2), they have recently reviewed their experience treating vestibular schwannomas in over 90 patients. There is no equivalent stereotactic radiotherapy experience and it should be stressed that the details and results described here relate specifically to the current Gamma Knife radiosurgical practice treating NF2 tumours in Sheffield.

Patients are generally referred from specialist services throughout the UK with details of how the individual's condition has progressed, recent MRI scans and audiogram information. In deciding whether an individual is potentially suitable for radiosurgery, tumour size is the main consideration as the larger a tumour is the less likely it is to respond to and be controlled by radiosurgery.

If a patient is thought to be potentially suitable for radiosurgery, they are offered a clinic appointment to come and discuss this. All new patients are seen by one of the three consultants who all have a specialist interest in radiosurgery and there is also opportunity in clinic to meet with and talk to the therapy radiographers. Whilst the majority of NF2 patients do attend clinic before treatment, and this is very strongly recommended, occasionally because of geographical considerations, patients wish to avoid the extra trip and are often admitted directly for treatment.

The treatment is carried out in a 2 night stay in hospital. Patients are admitted the day before treatment. On the day of treatment the stereotactic frame is fitted. This is the reference guide for the whole of the treatment and has to be rigidly fixed to the patient. This procedure is carried out with local anaesthetic, takes around 10 minutes and is very well tolerated. With the frame in place, an MRI scan is carried out and used to pinpoint the tumour and to map and plan the treatment. The treatment itself, which is likened by many patients to "having another scan", is then performed. The frame is used to position the patient very precisely on the bed, which then moves into a tunnel. It is less enclosed than an MRI scanner, and there is no inherent noise (although patients can listen to music, talk over an intercom etc). At the end of the procedure, the frame is removed. Patients who have travelled a considerable distance, they are generally kept overnight, before being discharged the following day. Local patients can be discharged on the day of treatment.

Follow-up is generally performed locally by the patient's referring specialist. It is recommended that all patients are followed up with MRI scanning but this, of course, is part of the normal NF2 follow-up.

Radiosurgery results in NF2

Unfortunately, it is well recognized that NF2 tumours are harder to treat surgically than sporadic unilateral ones and the same applies to radiosurgery. In assessing results and deciding on treatment options it is very important to consider and identify specifically NF2 patients and not to extrapolate from results achieved treating unilateral sporadic tumours which may be falsely optimistic. In an attempt to clarify what radiosurgery achieves in NF2, we have recently reviewed our total experience. [2]

We estimate that eight years after the radiosurgery:

- 20% of patients will have undergone surgery for the treated tumour.
- In 50% the tumour will have stopped growing or have shrunk.
- In 30% there will have been some variable concern about tumour growth, but that they will have been managed conservatively and will not have undergone surgery.
- 40% of patients will retain their functional level of hearing.
- In 40% there will be some deterioration in hearing.
- 20% become deaf in that ear.
- The risk of a persisting facial weakness is 5%.

Whilst these results are nowhere near as good as those achieved treating unilateral sporadic tumours, the evidence is that radiosurgery does slow the growth of NF2 tumours, and the hope is to control tumour growth or at least defer the need for surgery in the majority of patients. Given the morbidity and mortality associated with surgery, we believe that radiosurgery is an attractive treatment option for selected NF2 patients with growing tumours.

Common questions and concerns about radiosurgery

To some extent radiosurgery has been seen as competition for, and taking away work from skull base surgical practices. Individual surgeons vary greatly in how receptive they are towards radiosurgery and how they perceive its risks and benefits. This of course influences how the radiosurgery treatment option is portrayed to patients.

Questions which we are commonly asked include:

1. What is the risk of a radiation treatment causing malignancy?

We believe that the risk of this in the general population is very low indeed. To date there are only a few single patient case reports describing altered tumour behaviour after radiosurgery, and world-wide over 200,000 patients have been treated with the Gamma Knife, nearly 20,000 for vestibular schwannomas. Of course the majority of these patients will not have NF2, and the risk in NF2 may be different from that of the general population because of the genetic predisposition to form tumours. In treating over 120 NF2 vestibular schwannomas we have had one case whose tumour was not controlled by radiosurgery and who subsequently underwent surgery at which time the tumour had malignant features.[3]

Of note, this tumour was growing rapidly, increasing in volume some 15 fold in the two years before radiosurgery, so it is doubtful whether radiosurgery caused the malignant behaviour and atypical growth. Whilst we would not wish to underestimate it, we believe that the risk of malignancy is low, less than 1% in NF2, and much less than this in the general population. This figure has to be weighed against the mortality associated with open surgery.

2. What is the risk of radiosurgery causing scarring, and making subsequent surgery more difficult?

This is even harder to assess and quantify. The published literature is extremely anecdotal and relates to vestibular schwannomas in general, rather than to NF2. Individual surgeons have both reported surgery being harder and easier after radiosurgery (radiosurgery may decrease the blood flow through a tumour making an operation easier).

We are aware that some surgeons claim that there is always damage to the facial nerve after surgery if there has been previous radiosurgery. In evaluating these claims and making decisions about treatment, it is important to remember that it is the minority of patients who undergo radiosurgery who subsequently undergo surgery, and that in a review of British NF2 patients, most of whom had not undergone radiosurgery, 70% of patients had some degree of facial nerve dysfunction after surgery.[4]

3. Can radiosurgery be repeated?

This is often asked, particularly by patients who have had unfavourable surgical experiences. We have retreated two vestibular schwannoma patients, one a sporadic tumour and one an NF2 patient. Both at last follow-up appear to be controlled. We would stress however that this practice of repeating a treatment is very much the exception, and that each case has to be judged on its individual merits.

Making a decision

Management decisions in NF2 are difficult because there is no ideal treatment option. What is right for the individual patient will depend on the size of the tumours and how fast they are growing, what hearing is like in both ears, and on the individual's perception of the risks and benefits of the different management options. These options essentially are those of observation, deferring any active intervention; surgery, which carries the greatest immediate morbidity in terms of hearing loss and facial nerve function; and a stereotactic radiation treatment.

In this article we have tried to explore what we feel Gamma Knife stereotactic radiosurgery has to offer treating NF2 vestibular schwannomas. Theoretically, fractionated stereotactic radiotherapy may be kinder on the surrounding tissues (by allowing some recovery between fractions), and hence one might consider it for a larger tumour with significant brain stem compression. The concern however would be that in being kinder to the surrounding tissues, it may also be less effective in treating the tumour, and tumour control rates will be worse. There is no NF2 series evaluating this, nor is there any consensus of how many fractions with what dose should be used to treat either vestibular schwannomas in general, or NF2 tumours specifically.

The final decision rests with the patient. In making a decision we would however encourage the individual to have as many informed opinions as he/she finds helpful. We would hope that this article would clarify some of the issues surrounding radiation treatments.

JG ROWE FRCS(SN) Consultant Neurosurgeon

National Centre for Stereotactic Radiosurgery, Sheffield. 2003

References

1. Rowe et al. *Br J Neurosurg* 2002; 16: 477-82.
2. Rowe et al. *J Neurol Neurosurg Psych* 2003; 74: 1288-93.
3. Bari et al. *Br J Neurosurg* 2002; 16: 284-9.
4. Evans et al. *Q J Med* 1992; 304: 603-18.

Produced
with financial
support from



The Neurofibromatosis Association has taken reasonable care to ensure that the information contained in its publications is accurate. The Neurofibromatosis Association cannot accept liability for any errors or omissions or for information becoming out of date. The information given is not a substitute for getting medical advice from your own GP or other healthcare professional.

For more information and a full list of publications please contact:

The Neurofibromatosis Association Tel: 020 8439 1234 website: www.nfauk.org
Quayside House, 38 High Street Fax: 020 8439 1200 e-mail: info@nfauk.org
Kingston on Thames, Surrey KT1 1HL Mon — Fri 9am — 5 pm
National Telephone Helpline : 0845 602 4173

The Neurofibromatosis Association is a Registered Charity No. 1078790
and a Company Limited by Guarantee registered in England and Wales, Reg. No. 03798407