REPORT ON STEREOTACTIC RADIOSURGERY/RADIOTHERAPY WORKSHOP – 5 APRIL 2001
Final Version Approved by JWG 18 June 2001

This Report will be circulated to the delegates invited to the Workshop (Listed in Appendix 1) and Clinical Directors in Neurosurgical Units

1. Introduction by Prof Teasdale and Dr Carroll. **Background:** The Main objective of Joint Working Group is to develop and co-ordinate a National Perspective on Planning for Clinical Services in Neurosurgery, in the context of the recommendations of 'Safe Neurosurgery 2000'. The aim of the meeting is to inform the JWG about the current knowledge on the Gamma Knife (GK) and Linear Accelerator (LINAC) stereotactic radiotherapy.

2. The 'Gamma Knife Report' (Stereotactic Radiosurgery prepared by Mr Forster and colleagues) had been pre-circulated to the delegates – and Mr Andras Kemeny presented information based mainly on the 15 year experience in Sheffield.

3. LINAC Report – The Report ' Stereotactic Delivery of Radiation Therapy Using a Linear Accelerator' prepared by Prof Rampling and colleagues had been pre-circulated to the delegates and important aspects were highlighted at the Workshop.

4. Conclusions from Reports, Presentations and Discussion

- Both treatments are methods of Radiotherapy which aim to deliver ionising Radiation to destroy cells or to alter cell function whilst minimising risk to adjacent normal tissue
- Discussions before and during the meeting had shown substantial agreement about fundamental principles and points of correspondence allowing focus on areas of possible distinction
- The source of Radiation is different in the 2 approaches: GK uses γ ray photons from multiple high activity Cobalt-60 sources whilst LINAC uses X-ray photons derived from high-energy electrons produced in a linear accelerator. For practical purposes both energy forms are equivalent.
- Stereotaxy is a means of accurate delivery of an intervention to a localised target inside the head/*b*rain. Along with sharp definition of the boundaries of the field of delivery (collimation), Stereotaxy enhances the safety to adjacent tissue
- GK has very high (sub-millimetre) level of accuracy especially with small lesions. LINAC accuracy is around 1mm and advances in technology are improving this aspect. Accuracy of treatment is also dependent upon radiological target definition – typically 1.4m. These factors are additive so net accuracy is 2-3mm and therefore precision of delivery is essential.
- In current practice, Stereotactic Radiosurgery (SRS) is usually delivered as a single treatment of high dose Radiation (= single fraction Radiotherapy) with the aim of destroying the function of all tissue within the target in the case of tumours. Sub-lethal doses usually suffice with vascular or functional targets. The use of a single fraction is the choice of the user and is not determined by the machine.
- Alternatively the total administered radiation dose may be divided into smaller dose fractions = fractionated Stereotactic Radiotherapy (FSRT). Fractionation takes advantage of radiobiological principles to protect normal tissue and important structures within or closely related to the lesion at the expense of some precision of delivery.

- Whether or not treatment is fractionated is not equipment dependent. In practice the GK is used almost exclusively to deliver SRS whereas with a LINAC both SRS and FSRT are in use. Factors contributing to the choice of fractionation with LINAC are (a) inability to precisely delineate the target (tumour) and the need to preserve surrounding tissue and (b) SRT, being delivered by LINACs, is a technique familiar to radiotherapists.
- Most targets are irregular in shape. Protection of adjacent normal tissue is enhanced by a variety of methods designed to conform the irradiated volume to the target. These include the use of multiple beams, adjustment of the shape of the individual radiation beams (conformal therapy) and the use of multiple adjacent targets (multiple isocentres).
- SRS is most suitable for small (<3cm) well circumscribed lesions and is adaptable for irregular shapes. This adaptation is easier and quicker with GK than LINAC. Size limitation is based on configuration and location and not merely on maximum diameter. Tumours which infiltrate surrounding tissue eg malignant gliomas are less suitable for primary treatment with SRS. Despite precautions achieved by technology, adjacent normal tissue will be at risk of the harmful effects of Radiation. This risk increases with larger targets.
- In SRT additional protection of normal tissue is achieved by the appropriate choice of total dose, target dose uniformity and the use of fractionation. FSRT has advantages when large volumes of tissue (regular and irregular in shape) require treatment.
- Late induction of malignancy is a recognised complication of radiotherapy of the brain and may occur after both SRT and SRS, although likely to be rare, precise information is not yet available.
- **Clinical Applications**
    1. AVM's – SRS is firmly established as a useful component in a management strategy in which a multidisciplinary approach to treatment is crucial. Treatments used to reduce the risk of re-bleeding can include microsurgery, interventional radiology and radiotherapy. Most clinical experience is with GK and the wisdom and judgement developed in Sheffield are valued by Neurosurgeons throughout Britain. Expected workload is around 300-500 cases per year. A complete obliteration rate of around 88% at 5 years was reported by the Sheffield Team leading to eradication of re-bleeds, with 3% complications. These lesions are unsuitable for fractionation.
    2. Acoustic Tumours – Microsurgery is the standard treatment; some small tumours can be kept under surveillance but SRT is increasingly an option chosen by some patients. Again, most experience is with GK SRS. Expected workload needing treatment is up to 400 per year. Tumour 'control rate' with SRS was reported to be around 90-95% for lesions < 3 cm with around 30% becoming smaller; facial nerve injury occurs in 5-6%. SRS is cheaper than Surgery. FSRT may also be effective and possibly safer but more expensive and the reported experience is less.
    3. Pituitary Tumours (Macroadenoma) – Standard RT is long established as a safe and effective method of treatment after incomplete resection or as treatment for recurrence. SRS can also achieve tumour control but without clear advantage over standard treatment. The risk of damage to optic nerves with SRS makes clear anatomical separation vital and limits its role. Workload is 400-600 patients per year. Possible benefits from SRT over standard radiotherapy may justify expansion of SRT facilities to treat this condition.
    4. Cerebral Metastases – Estimated 15,000 patients per year to be considered for treatment. Not all patients are suitable for SRS treatment. This will be determined by the major determinants of outcome which include the number of metastases present, whether the primary tumour is controlled and the general condition of the patient. In the treatment of small, single cerebral metastases (or small numbers) SRS is an alternative to surgical excision. It has the advantage of lower cost and is applicable to deep lesions and frail patients. Local 'control' is achieved in 60-80% of patients. The benefit of additional Whole Brain Radiotherapy (WBRT) is uncertain.

5. Meningioma – Workload could be up to 400 patients per year. Radiotherapy is indicated when surgical resection is incomplete or not intended (e.g. skull base and parasaggital areas) and reduces recurrence. FSRT is the treatment of choice for larger lesions and those intimately related to vital structures or surface spreading disease). FSRT or SRS may be used for small lesions with clear separation from vital structures. 80% tumour control is reported with SRS.
6. Malignant Brain Tumours (Glioma) - Workload is 1,600-2,000 per year. These tumours infiltrate the brain beyond the edge visible on a CT/MR scan and therefore, are not suited to SRS. Conventional radiotherapy is normally used but SRT may be of benefit in some circumstances, especially in children. SRS and FSRT have been used as a boost to conventional RT or as primary treatment for recurrence. No clear benefit has been shown to result from this practice and clinical trials are in progress.
7. Functional Disorders – The potential workload is high (eg 1,000 – 1,500per annum for Trigeminal Neuralgia and 1,000 – 2,000 for epilepsy). Benefit is reported but the role of SRT/SRS is not yet established. The majority of work reported is from Gamma Knife Units.

Features of Gamma Knife

Pros:

1. Reliable, robust 'Workhorse' machine, cheap to run.
2. High patient throughput for SRS in most units.
3. High level of accuracy of delivery.
4. Ease of excluding vital structures from target.
5. Short(1-2 days) stay in hospital or out-patient if local.

Cons:

1. Expensive to install and replace.
2. Less suitable for larger (>3cm) targets.
3. Size of target also determines efficacy and safety.
4. Not suited to fractionated treatments.
5. Potential for further technological development limited.

Features of LINAC

Pros:

1. Ease of treating large lesions.
2. Suited to fractionated treatments, conformal and beam intensity modulated treatments. Most modern LINACs capable of stereotactic delivery, hence potentially widely available.
3. Versatile.
4. Further technological advances anticipated.

Cons:

1. Higher level of technology, more maintenance required, less reliable and more frequent down time.
2. Moving parts – therefore potentially less accurate.
3. Increased quality control needed especially if not dedicated.
4. Slower throughput for SRS in most units.
5. Subject to competition from demands for treatment of non neurological cancers.
6. Risk of dilution of experience because of lack of dedication and reduced throughput.

5. Issues for Planning

- Trent Region decision to replace GK at Sheffield with LINAC eventually; GK services if needed to be purchased elsewhere. This decision was apparently not based on clinical recommendations.
- The number of patients needing treatment for AVM's is likely to be stable but increasing in the case of tumours.
- Anticipated technological advances of LINAC expected to enhance its applications.
- Decision needs to be made if there is an absolute need on radiobiological grounds for GK SRS.
- Workforce factors important; dedicated teams of highly trained personnel needed for both methods.
- Not much support for another GK in London by RSCG's (Cromwell Unit has a service for NHS & Harley Street Unit has similar costs. SE London unit intending to purchase a GK to supplement LINAC).
- LINAC will have increasing demands for treatment of other cancers, potentially competing with use for Central Nervous System (CNS).
- Concept of utilising money saved by not performing conventional surgery to fund SRS/SRT considered unacceptable by clinicians (= 'deficit shifting').
- Patient throughput is likely to remain substantially higher for GK SRS than LINAC FSRT.
- GK becomes cost effective if a minimum of 150 patients are treated per year.
- No plans to purchase a GK unit for Scotland at present.

Disease	**Approximate Annual Incidence in UK (population 65m)**	**Estimated number potentially requiring treatment with SRS/SRT per year**
AVM	1,300	300
Acoustic Tumour	600	60-400
Pituitary Tumour	1,200	400-600
Metastases	45,000	10-15,000
Meningioma	1,200	400
Malignant Glioma	2,500	1,600-2,000
Trigeminal Neuralgia	3,000	1,500
Parkinsons Disease	8,000	?
Epilepsy	50,000	2,000

Summary & Conclusion of JWG, 21st May 2001

1) SRT has well established role and this is likely to increase
2) Clinical efficacy of SRT with either GK or LINAC is capable of being comparable in many circumstances.
3) Throughput of patients characteristically higher in a GK unit.
4) Some preference for GK for certain uses of SRT – (eg smaller, central, well demarcated targets separated from 'vital' structures) & LINAC for others (eg peripheral, larger targets needing fractionation).
5) GK preferences associated with benign lesions suitable for 'cold', elective treatment; LINAC preferences associated with lesions needing rapid intervention, in 'sicker' patients, less able to travel.
6) The use of SRT in the management of patients with certain lesions eg AVM or benign brain tumour should be centred in a small number of designated Supra Regional services; such centres will be expected to undertake prospective audit and to report their results.
7) SRT services supplied at Regional level are likely to need expansion for treatment of other CNS disorders, and for other cancers eg head and neck.
8) Guidance for Commissioners needs to be drawn up, in accord with foregoing.