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Canadian Association of Radiation Oncology

Association canadienne de radio-oncologie

Radiosurgery Scope of Practice in Canada

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Radiosurgery Advisory Committee

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CONTENTS

A. Background

In 2008, the CARO Presidency requested that a working group be formed to define the role of the radiation oncologist in the practice of radiosurgery (RS). This statement follows a 2004 document defining the scope of practice of radiation oncologists in Canada and a 2006 American College of Radiology/American Society for Therapeutic Radiology and Oncology (ASTRO) guideline for the practice of RS.

RS has a long history dating back to the 1940s when Dr. Lars Leksell designed an initial application based on kilovoltage x-rays. In 1954, the first in a long series of patients were treated with charged particles, many of these patients were women treated with pituitary ablation in the management of metastatic breast cancer. A decade later this was followed by treatment via dedicated cobalt units using a large number of crossfiring sources [1]. In the 1980s, RS became more widely available with the use of modified linear accelerators [2, 3] and is now widespread in oncology centers around the world.

From the 1940s to the 1980s, the differences between radiosurgery and conventional radiation treatments were striking. In the years since, rapid evolutions in standard radiotherapy units and dedicated radiosurgery accelerators have blurred the line between conventional and stereotactic radiation. In many cases, this has freed clinicians from the previous forced choice between precise single fraction treatments and non-selective fractionated treatments [4, 5]. Most recently, image-guidance systems have, in some cases, eliminated the surgical act of frame placement and erased the last remaining differences between single-fraction and fractionated delivery.

Since its inception, RS has been applied to a number of benign and malignant intracranial tumors. In certain cases, RS is meant to exploit the biology of a large single fraction (for example, RS for vascular malformations), and in others the use of a single fraction is a convenient way to provide high dose radiation in a timely manner for patients in a palliative setting (brain metastases). Although cranial RS is most commonly used for oncological applications, it has been used for a variety of other pathologies beyond traditional vascular indications, including pain syndromes [6, 7], opthalmological diseases [8, 9] and movement disorders [10, 11].

For the purpose of this document, RS is defined as the precise application of a single, high dose of radiation to a small intracranial target. The application of multiple fractions to the same target in order to exploit the traditional radiobiology of radiotherapy is not, in the opinion of the workgroup, RS. This is consistent with the 2002 report of the American Society or Radiology and Oncology working group on scope of practice [12]. However, the staged single fraction treatment of different subvolumes of a large target would fall under the scope of RS. Treatment of extra-cranial lesions was specifically excluded from the scope/mandate of this report.

B. Introduction

Primarily, the purpose of this document is to initiate a discussion of how our specialty can meet the needs and interests of RS patients, safely, efficiently, and competently. It is the prerogative of CARO to undertake this process independently in order to allow the specialty to ready itself for the continued evolution of the practice of RS. Scopes of practice determinations have been of use to stakeholders such as CARO in discussing with government, cancer care organizations and regulatory bodies the role of the specialty.

There is extensive literature on the notion of scope of practice. Much of the literature focuses on scope of practice of physicians and nurses; however, it is clear there are many other professional groups that have overlapping scopes of practice. The definition for scope of practice is "…the activities for which the professional is educated, and authorized to perform; and is influenced by the setting in which the professional practices, the requirements of care delivery organizations, the needs of the patients or clients" [13]. Thus the notion of scope of practice reflects essentially the practice of the profession and is used as a guide to the profession and public.

Past and present - Radiosurgery in Canada

Cobalt radiotherapy was first introduced in Canada in the 1950s and inspired the design of the first Leksell-Larsson Gamma Knife based on these more penetrating rays. Although the first commercially developed Gamma Knife, the model U, was only produced in 1987, 1985 saw the development at McGill of a new Linac-based radiosurgery technique. The impetus for this development came from Dr André Olivier, neurosurgeon at the Montreal Neurological Hospital. With the help of a team of physicists (Drs Podgorsak, Peters, Pla, Olivares and Pike), Dr Hazel – radiation oncologist, technicians and an electronics engineer, an initial patient was treated with a coplanar technique before the now well-know dynamic stereotactic technique was implemented in 1986.

The 1990s saw other centers implement the Montreal radiosurgery planning system and dynamic technique; first in Toronto, following the interest of Dr Schwartz and then in London. The first patient treated in London underwent radiosurgery in February 1991. At the time, this was done using a modified LINAC with a floor mounted stand. Patients treated were at the time were primarily those with recurrent glioma, AVM and brain metastases. With improvements in couch design and stability, in 1997, the London technique was moved to a couch mounted system.

In the following years, other radiosurgery programs were created across Canada using commercial systems for the planning and delivery of treatment with modified linear accelerators. As an example, in 1997, the British Columbia Cancer Agency's provincial stereotactic radiosurgery program began operation in Vancouver using a commercial cone-based system.

Although, as early as 1987 patients were treated in Montreal with 6 fractions over 2 weeks, the use of hypofractionation remained uncommon at a time where invasive fixation was required.

Following the era of cone-based techniques on modified linear accelerators, in 1999, the first of many Canadian micro multileaf (mMLC) collimators was installed in Toronto to be used with single fraction RS cases and fractionated stereotactic radiotherapy cases. Although in the year 2000 both mMLC and cone-base techniques co-existed in Montreal and Toronto, the London technique using invasive frames with custom circular collimators was decommissioned in favor of a non-invasive technique using an mask immobilization system, portal imaging and real time optical guidance combined with a dynamic arc technique using a multileaf collimator. In 2002 treatment with RS began in Halifax at the Nova Scotia Cancer Centre. The program is run jointly by neurosurgery and radiation oncology and utilizes a linear accelerator with micro multileaf collimators and a dedicated planning system. In 2004, a helical tomotherapy unit was installed in London and this has increasingly become the platform for image guided SRT for brain metastases, selected recurrent glioma and "benign" tumors such as meningioma and acoustic neuroma. The Alberta radiosurgery program had used a cone-based system for 3 years when it installed the first Canadian commercially dedicated radiosurgery LINAC in 2004. This BrainLab Novalis remains in service to this day.

In 2003, the Winnipeg Regional Health Authority commissioned the installation of Canada's first Gamma Knife, a Model C with APS, at the Health Sciences Centre in Winnipeg. In 2004, the second Canadian Gamma Knife unit was installed at the Centre Hospitalier de l'Université de Sherbrooke. The same year, a BrainLab Novalis system was installed in the new Alberta Radiosurgery Center at the Tom Baker Cancer Center in Calgary. In 2005, the University Health Network opened the 3rd Canadian Gamma Knife unit as a joint collaboration between the Radiation Medicine Program, Princess Margaret Hospital, and the Krembil Neuroscience Center based at Toronto Western Hospital. This program was funded as a provincial resource for the delivery of radiosurgery for benign neurosurgical disorders including benign tumors, AVMS, as well as functional neurosurgical applications in pain syndromes, movement disorders, and epilepsy. In 2007, Princess Margaret hospital received the 4th Gamma Knife Perfexion unit in Canada and migrated their cancer radiosurgery program from linear accelerator systems to this new platform.

In what may be the beginning of a fourth wave of Canadian RS systems, following a dedicated pedestal-based system and a tertiary micro MLC collimation system, le Centre Hospitalier de l'Université De Montréal accepted delivery in 2009 of the first Canadian CyberKnife frameless RS system. The first patient treatment on this robotic radiosurgery unit was delivered in June 2009. Another stereoscopic image-guided robotic device, the Novalis Tx, will replace the mMLC and cone-based programs at McGill in 2009-2010.

Current practice in Canada has followed the technology used for the delivery of RS. Programs based on Gamma Knife technology tend to have a stronger neurosurgical involvement. Programs built around a dedicated or modified linear accelerator tend to be located in radiotherapy departments. Treatments delivered without the use of invasive immobilization and fractionated stereotactic radiotherapy (FSRT) are almost always delivered under the exclusive supervision of radiation oncologists while frame-based treatment are either supervised by a radiation oncologist or delivered jointly with neurosurgery.

Scope of Practice

Many health care tasks overlap between professions. Formal discussions about inter-professional roles and responsibilities and their potential evolution have begun in some countries (e.g. United Kingdom), and will increasingly occur in the Canadian environment.

In 2001, faced with issues including the treatment of functional CNS lesions with RS, the increasing use of radiation in vascular diseases, growing patient consumerism and private delivery of radiation services, the CARO Board of Directors requested that the Manpower and Standards of Care Committee consider an initiative to define the scope of practice that should be encompassed within the specialty of Radiation Oncology. This directive was taken at a time in which numerous professional bodies, including the Canadian Medical Association and the American Society of Therapeutic Radiology and Oncology had made it a priority to outline principles and criteria for determining scopes of practice [12, 14].

The subsequent 2006 report concluded that radiation oncologists, by virtue of comprehensive training and experience, have a unique responsibility to oversee the use of ionizing radiation in the treatment of malignant and benign disease. It defined the radiation oncologist as a physician with clinical competence and experience in the acute and chronic biological effects of radiation on both neoplastic and normal tissues and included in the scope of practice:

- The recognition that the radiation oncologist has a solid background in the sciences basic to the understanding of malignant diseases.
- Is well versed in the physical and biological mechanisms of radiation and other anticancer modalities, and their modulation by physical, pharmacologic and biologic agents.
- Is expert and technically proficient in the therapeutic uses of radiation, including expertise in radiation dose, fractionation and timing, mode of administration, and integration with other anticancer modalities.
- Has expert clinical skills in the care of both ambulatory and hospitalized patients, and is integral to coordinating care with primary care physicians, specialists from other oncologic disciplines, and other members of the health care team.
- Is knowledgeable in the diagnosis and treatment of acute and chronic morbidity associated with ionizing radiation.
- Is able, in association with radiation physicist, radiation dosimetrists, radiation therapists and radiation oncology nurses, to develop standards for radiation safety and efficacy, and utilize such standards to integrate useful emerging technologies with regard for radiation protection of patients, members of the health care team and the general public.
- Is increasingly subspecialized in both a tumor-specific and modality-specific sense recognizing the pace of development in the field.

In the same report, it was also specifically recommended by CARO that:

- Radiation oncologists should be skilled in the planning and delivery of stereotactic radiation using linear accelerator and gamma-isotope based techniques.
- Radiation oncologists should participate, either directly or as consultants to other medical specialists and health professionals, in the long-term care and follow-up of patients with benign conditions treated with ionizing radiation. This, to assure optimal patient care and ongoing quality assurance.
- Radiation oncologists should be familiar with the purpose and scope, benefit, and regulatory requirements associated with technical quality assurance protocols that are widely accepted in the field. Technical quality assurance encompasses: 1) measurement of planning, delivery and verification of equipment performance characteristics; 2) comparison of equipment performance characteristics with existing technologic standards and established specifications; and 3) identification of appropriate tolerance limits, action levels, and procedures to maintain or regain equipment performance. Radiation oncologists also require an understanding of computer systems and medical informatics, which are the underpinnings of current and developing targeted treatment planning and delivery systems.

CARO recognized that the scope of radiation therapy applications in non-malignant disease is broad, ionizing radiation being a unique therapeutic modality with anticancer, antiproliferative, immunosuppressive, anti-inflammatory and antivascular effects. Radiation oncologists were deemed to have the training, experience and competence to best assess the benefits and risks of using radiation in the treatment of non-malignant and benign diseases, and assure appropriate treatment delivery. The scope of practice specifically included the potential use of radiosurgery in the management of benign intracranial disease processes and functional neurological disorders, specifically including (nut not limited to): cranial nerve schwannoma, meningioma, arteriovenous malformations, cavernous angioma, pituitary adenoma, low-grade glioma and trigeminal neuralgia.

The report recognized that radiation oncology in Canada continues to develop new generations of specialists through formally evaluated and accredited training programs, including certification of competence by the Royal College of Physicians and Surgeons of Canada (RCPSC) and ongoing maintenance of competence programs. The RCPSC Office of Education has itself defined radiation oncologists as:

- Medical specialists with unique knowledge, understanding and expertise in the diagnosis of patients with malignant disease
- Physicians integrally involved in the formulation and execution of the management plan of cancer patients
- Specialists, using an evidence-based approach, responsible for the appropriate recommendation, prescription and supervision of the therapeutic use of ionizing radiation.
- Physicians which should be responsible for the competent and ethical discharge of these responsibilities resulting in improved quality of life and/or survival for cancer patients, in turn benefiting families, society and future care.

Contributions of Neurosurgeons to the Field of Radiosurgery

Internationally and in Canada, neurosurgeons have provided a large part of the motivation for the development and application of radiosurgery.

From the first concept of Dr Leksell to design a way to harness ionizing radiation as a means of lesioning the brain to the modern vision of Dr Adler to use a robotically mounted linear accelerator, surgeons have been innovators in the technology of not only of radiosurgery but of radiotherapy in general.

Neurosurgeons have also innovated in applying RS to new pathologies and have challenged the paradigm that therapeutic radiation must be delivered homogeneously. The have collaborated with radiation oncologists in radiation oncology cooperative groups to provide the sparse but meaningful multi-institutional prospective data which helps guide current practice.

RADIOSURGERY – Current and Future Trends

Despite the different technologies, until recently all radiosurgery shared several commonalities. Patients were immobilized using an invasive halo or “frame” with external stereotactic fiducials. Patients were imaged on the day of frame placement. Depending on the planning system, this imaging study may have been co-registered to pre-frame placement images. With the help of the medical physicist, multiple convergent isocentric beams were planned to be delivered to one or multiple isocenters. Treatment was delivered under direct physician supervision and the frame was removed prior to patient discharge.

Technological Improvements

As mentioned in the background, an important trend is the convergence of standard radiotherapy with so-called stereotactic radiotherapy. When imagined by Dr Leksell in the 1940s and first delivered with charged particles or convergent gamma rays, radiosurgery was a radical departure from conventional radiotherapy of the day. At the time, the alternatives to single fraction, highly conformal, highly accurate radiosurgery were interstitial treatments or limited-field irradiation with kilovoltage x-rays. Even in the mid-80s, when patients were first treated with radiosurgery in Canada, the alternative radiotherapy treatments could still involve cobalt treatments with 2D planning. In 2009, the difference in the accuracy and conformality of advanced radiotherapy and radiosurgery is fading. With the trend away from invasive immobilization and towards image-guidance, physicians will no longer have to choose between the potential biological benefits of fractionated treatments and the normal tissue-sparing dose characteristics of radiosurgery. More and more, physicians will have to ponder whether patients treated with oncological applications would not benefit from hypofractionated stereotactic radiotherapy over traditional RS.

As many of the concepts of RS have been integrated into radiotherapy, there has also been a reverse pollination of radiotherapy advances into certain radiosurgery devices. Initial treatments with linear accelerators mimicked treatments delivered on dedicated cobalt units through the use of arcing conical collimators. Currently radiosurgery can be delivered with more uniform dose, through fine multileaf collimators, using inverse planning, fluoroscopic and CT image-guidance.

In 2009, one person's fractionated stereotactic radiotherapy is another's standard radiotherapy. The American Association of Neurological Surgeons and the Congress of Neurological Surgeons have taken a position arbitrarily bringing hypofractionated stereotactic radiotherapy of up to 5 fractions under de umbrella of "radiosurgery"[15]. This position on semantics, subsequently recognized by third party payers, may have had beneficial effects in removing a disincentive for certain physicians to use fractionation, encouraging tighter collaboration between surgeons and radiation oncologists and increase referrals for radiation treatment but it has no convincing biological basis, it creates a perverse incentive to choose a specific fractionation and devalues the extensive training which radiation oncologists have in the application of therapeutic irradiation.

Frameless Image-Guided Radiosurgery

The invasive stereotactic head-frame has been the standard for RS given the rigid immobilization it provides of the patient's head, and the stereotactic coordinates needed to precisely localize the target in three dimensions. Recent technologic advances have led to the development of "frameless" RS. Frameless RS implies single fraction treatments delivered without the use of an invasive head-frame, and has arisen with the development of CT based treatment planning and image-guidance.

This practice is evolving and early reports suggest similar outcomes to patients treated with frame-based RS[16-21]. Both dedicated micro-multileaf linear accelerator based systems with image guidance [16, 17, 20-23] and a dedicated robotic RS LINAC [18, 19] have been purchased in Canada for the purpose of frameless RS. Recently, Gamma Knife technology has also evolved to incorporate a non-invasive relocatable head frame (publications pending).

The technical process of frameless RS is more in keeping with high-precision radiotherapy than radiosurgery although the indications and biology are those of traditional RS. The potential advantages of replacing the invasive head frame include improved patient convenience and comfort, imaging verification independent of the immobilization device, as well as improved work-flow, allowing complex treatment planning (including inverse-planning) and quality assurance to be performed without time pressure.

The removal of the surgical application of the stereotactic frame from the treatment process is likely to have an unintended impact on the role of the Canadian neurosurgeon in RS.

Dedicated Radiosurgery Linear Accelerators

With the development of indications for RS and stereotactic radiotherapy in the rest of the body, new RS devices are being built with extra-cranial treatment capabilities. These complex devices, which may be used to treat the prostate as well as the brain, are more likely to be physically installed in radiotherapy departments than dedicated radiosurgery centers. In this context, additional efforts may be required to maintain a team approach to cranial radiosurgery.

C. Role of the Radiation Oncologist in Radiosurgery Treatments

All patients can benefit from a team approach to their care. Within the radiotherapy department, treatments would not be possible without the input of radiotherapy technologists, medical physicists, nursing staff, allied health professionals, support staff and physicians. More broadly, cancer patients are often managed by a team of physicians — surgeons, medical oncologists/hematologists and radiation oncologists. Quality care most often requires sub-specialized opinions from specialists in pathology, radiology and other medical specialties on a disease-specific basis. In general, patients are thought to benefit from a formal discussion of their cases amongst these health care professionals, often in the form or tumor boards or patient management rounds.

Optimal cranial RS teams involve radiation oncologists, neurosurgeons and medical physicists working as peers. Treatment delivery is made possible by additional input from radiotherapy technologists, radiologists, nursing staff, engineers, allied health professionals and support staff. The extent to which the radiation oncologist will be involved in each step of the RS treatment may vary based on the individual's experience, training and interests as well as the pathology treated. However, the radiation oncologist practicing RS should strive to maintain and develop wide RS competence. The radiation oncologist is an expert in the therapeutic uses of radiation and should be able to perform or supervise all steps of the RS procedure.

In defining scope of practice, the Canadian Medical Association has proposed that the following criteria be taken into account [14]:

Accountability: Scopes of practice should reflect the degree of accountability, responsibility and authority that the health care provider assumes for the outcome of his or her practice.

Radiation oncologists have taken and should continue to take final responsibility to sign off on all radiosurgery prescriptions. Legislation relevant to radiosurgical practice includes the Canadian Nuclear Safety Commission, responsible for the licensing of radiotherapy units using radioactive isotopes (i.e. Cobalt 60) and high energy (>10 MV) linear accelerators. Licensing of such units requires identification of a Most Responsible Physician, typically the Radiation Department Head associated with the commissioning and quality assurance of the Unit. In addition, specific Provincial regulations exist for the administration of radiotherapy. For instance, in Ontario, the Healing Arts Radiation Protection (HARP) Commission Quality Assurance Guidelines set in 1997 specify in section 4.2.2: "Persons with direct responsibility for the provision of radiation treatment services to patients should be either a qualified radiation oncologist, a registered radiation therapist or a qualified medical physicist as appropriate. All others who participate in the provision of radiation treatment services should have direct accountability to a member of one of the above groups"; 4.2.6: "the individual in charge of the clinical aspects of a radiation oncology program should be a qualified radiation oncologist".

Although specific tasks may be undertaken by other health care processionals, the radiation oncologist oversees the procedure from case selection through follow-up and should have a key leadership role with respect to RS units.

Education: Scopes of practice should reflect the breadth, depth and relevance of the training and education of the health care provider. This includes consideration of the extent of the accredited or approved educational program(s), certification of the provider and maintenance of competency.

The radiation oncologist performing radiosurgery in Canada will have obtained and maintained accreditation through the Royal College of Physicians and Surgeons of Canada, or Le College des Médecins du Québec. These bodies recognize that radiation oncologists, using an evidence-based approach, are trained to be responsible for the appropriate recommendation, prescription and supervision of therapeutic ionizing radiation. In addition to their understanding of malignant diseases and their treatment, they are trained in regards to the natural history and pathology of those benign conditions that may be treated by radiation. If a particular physician's residency training did not include RS, then specific training in RS will have been obtained prior to performing any radiosurgical procedures. In addition the radiation oncologist may have obtained vendor-specific training for certain delivery systems.

Competencies and Practice Standards: Scopes of practice should reflect the degree of knowledge, values, attitudes and skills of the provider group.

It is the responsibility of radiation oncologists to establish the appropriateness of all radiation treatments with respect to efficacy and patient safety.

Quality Assurance and Improvement: Scopes of practice should reflect measures of quality.

Radiation oncologists are be familiar with the purpose and scope, benefit, and regulatory requirements associated with technical quality assurance protocols that are widely accepted in the field. Technical quality assurance encompasses: 1) measurement of planning, delivery and verification of equipment performance characteristics; 2) comparison of equipment performance characteristics with existing technologic standards and established specifications; and 3) identification of appropriate tolerance limits, action levels, and procedures to maintain or regain equipment performance. Radiation oncologists are also involved in clinical quality assurance and review of their practice.

Role of the Canadian Radiation Oncologist in the Practice of Radiosurgery

In keeping with the spirit of previous American Society for Radiation Oncology (ASTRO, previously the American Society of Therapeutic Radiology and Oncology) guidelines, this group is of the opinion that:

1. The radiation oncologist should participate in initial treatment decision-making, including the choice of therapeutic modality, integration with other treatments and the timing of RS.

2. Choosing or participating in the choice of immobilization device. If trained and competent in the procedure, installing or assisting in the installation of the stereotactic frame (when a frame is used). Supervising patient imaging and, if necessary, image registration.

3. If necessary, in concert with the neurosurgeon, neuro-radiologist or other physicians, specifying the target volume and relevant critical normal tissues. This collaboration is especially important for complex and functional targets.

4. Developing or participating in plan development and approving the final treatment plan.

5. Prescribing the radiation dose.

6. Ensuring that patient positioning on the treatment unit is appropriate.

7. Attending and directing the radiosurgical treatment delivery.

8. Following the patient and participating in the monitoring of disease control and complications.

9. Ensuring that radiosurgical acts are subject to a clinical quality assurance/quality improvement process. As well, radiation oncologists should be familiar with the purpose and scope, benefit, and regulatory requirements associated with technical quality assurance protocols that are widely accepted in the field. Technical quality assurance encompasses: measurement of planning, delivery and verification of equipment performance characteristics; comparison of equipment performance characteristics with existing technologic standards and established specifications; and identification of appropriate tolerance limits, action levels, and procedures to maintain or regain equipment performance.

Specific Pathologies

Although the radiation oncologist is trained and qualified to treat a wide range of malignant and benign disease processes with ionizing radiation, his role may vary in regards to specific pathologies treated with RS.

Treatment of Brain Metastases

As with most cancer care, many patients will benefit from the multidisciplinary medical management of metastatic disease and this may involve the participation of neurosurgeons, neuro-oncologists, medical oncologists, neurologists and/or palliative care physicians.

The radiation oncologist is a specialist trained in the management of a wide range of oncological diseases. Approximately half of all cancer patients will be treated with radiation at varying stage of their disease. Radiation oncologists are often involved in patient care from early diagnosis to end of life and are trained to discuss a variety of treatment options.

The radiation oncologist specializing in radiosurgery has the competence to diagnose brain metastases, evaluate the patient, weigh treatment options, inform the patient and deliver treatment. The radiation oncologist can offer and combine treatment with: clinical trials, RS, external bream radiotherapy and/or fractionated stereotactic radiotherapy. In those patients for which radiosurgery is felt to be of potential benefit, the radiation oncologist has the training to identify the radiosurgery targets, segment normal structures, prescribe, evaluate and supervise a radiosurgery plan. He is trained to offer follow-up, diagnosis and management of complications, evaluation of recurrences and supportive care as needed. He is willing to seek input from other specialists (neurosurgery, neuroradiology) to inform the treatment planning and delivery process as necessary.

Treatment of Benign or Malignant Primary Brain or Skull Base Tumors

The radiation oncologist is a specialist trained in the management of a wide range of oncological disease, benign and malignant. As with most cancer care, many patients will benefit from the multidisciplinary medical management of brain/skull base tumors and this may involve the participation of neurosurgeons, neuro-oncologists, medical oncologists, endocrinologists and/or neurologists.

Most patients with skull base or brain tumors will require surgical assessment if not intervention, however the radiation oncologist specializing in radiosurgery has the competence to evaluate the patient, weigh treatment options, inform the patient and deliver treatment. When intervention is indicated, the radiation oncologist can offer treatment with RS, external bream radiotherapy or fractionated stereotactic radiotherapy. In those patients for which radiosurgery is felt to be of potential benefit, the radiation oncologist has the training to identify the radiosurgery targets, segment normal structures, prescribe, evaluate and supervise a radiosurgery plan. He is trained to offer follow-up, diagnosis and management of complications, evaluation of recurrences and supportive care as needed. He is willing to seek input from other specialists (neurosurgery, neuroradiology) to inform the treatment planning and delivery process as necessary.

Treatment of Vascular and Functional Neurological Disorders

Although the radiation oncologist is trained in the application of radiotherapy and radiosurgery in the management of benign lesions, he will rarely be an expert in the overall management of vascular malformations, neuralgia or movement disorders. The roles of medical therapy, endovascular therapy, surgery and radiosurgery are constantly evolving. Not all patients will require treatment and those who do are best managed in a specialized center by a multidisciplinary team. When joint assessments are not possible, sequential referrals to medical specialists may be necessary. Once radiosurgery is selected as a treatment modality, this is most often best delivered in collaboration with a neurosurgeon, neuro-radiologist or neurologist.

D. Recommendations

Qualifications of the Radiation Oncologist

The radiation oncologist performing radiosurgery in Canada will have obtained and maintained accreditation through the Royal College of Physicians and Surgeons of Canada, or Le College des Médecins du Québec. If a particular physician's residency training did not include RS, then additional specific in RS will have been obtained prior to performing any radiosurgical procedures. In addition the radiation oncologist may benefit from vendor-specific technical training for certain delivery systems.

Role of the Radiation Oncologist

The radiation oncologist will be involved in all initial patient consultation and in the selection of appropriate patients for the appropriate treatment: frame-based versus frameless radiosurgery and single-fraction radiosurgery versus fractionated stereotactic radiotherapy. The radiation oncologist is encouraged to work in collaboration with neurosurgeons and other medical specialists in a multidisciplinary setting, especially when treating vascular and functional disorders.

The radiation oncologist will be involved in the establishment of a new radiosurgery program and in the selection of the radiosurgery hardware and software. The radiation oncologist will also insure that radiosurgical acts are subject to a clinical quality assurance/quality improvement process. As well, radiation oncologists should be familiar with the purpose and scope, benefit, and regulatory requirements associated with technical quality assurance protocols that are accepted in the field.

For individual radiosurgery cases, the radiation oncologist assumes responsibility for appropriate, safe and quality treatment delivery. Specifically, the role of the radiation oncologist should not be to summarily "approve" a treatment prescription, rather should include:

1. The radiation oncologist should participate in initial treatment decision-making, including the choice of therapeutic modality, integration with other treatments and the timing of RS.

2. Choosing or participating in the choice of immobilization device. If trained and competent in the procedure, installing, or assisting in the installation of the stereotactic frame (when a frame is used). Supervising patient imaging and, if necessary, image registration.

3. Specifying the target volume and relevant critical normal tissues. This may be done in collaboration with the neurosurgeon, neuro-radiologist or other physicians.

4. Developing or participating in plan development and approving the final treatment plan.

5. Prescribing the radiation dose.

6. Ensuring that patient positioning on the treatment unit is appropriate.

7. Attending and directing the radiosurgical treatment delivery.

8. Following the patient and participating in the monitoring of disease control and complications.

It is recommended that the work of the radiation oncologist as well as that of other physicians be documented in the patient chart.

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F. References

1. Leksell L: Stereotactic radiosurgery. J Neurol Neurosurg Psychiatry 1983, 46:797-803.
2. Colombo F, Benedetti A, Pozza F, Avanzo RC, Marchetti C, Chierego G, Zanardo A: External stereotactic irradiation by linear accelerator. Neurosurgery 1985, 16:154-160.
3. Podgorsak EB, Olivier A, Pla M, Hazel J, de Lotbiniere A, Pike B: Physical aspects of dynamic stereotactic radiosurgery. Appl Neurophysiol 1987, 50:263-268.
4. Adler JR, Jr., Chang SD, Murphy MJ, Doty J, Geis P, Hancock SL: The Cyberknife: a frameless robotic system for radiosurgery. Stereotact Funct Neurosurg 1997, 69:124-128.
5. Yin FF, Zhu J, Yan H, Gaun H, Hammoud R, Ryu S, Kim JH: Dosimetric characteristics of Novalis shaped beam surgery unit. Med Phys 2002, 29:1729-1738.
6. Barcia-Salorio JL, Roldan P, Lopez-Gomez L: Radiosurgery of central pain. Acta Neurochir Suppl (Wien) 1987, 39:159-162.
7. Gorgulho AA, De Salles AA: Impact of radiosurgery on the surgical treatment of trigeminal neuralgia. Surg Neurol 2006, 66:350-356.
8. Leung DY, Luk FO, Lam DS: Glaucoma treated by gamma knife irradiation. J Neurosurg 2005, 103:192; author reply 192-193.
9. Liscak R, Vladyka V: Radiosurgery in ocular disorders: clinical applications. Prog Neurol Surg 2007, 20:324-339.
10. Duma CM, Jacques DB, Kopyov OV, Mark RJ, Copcutt B, Farokhi HK: Gamma knife radiosurgery for thalamotomy in parkinsonian tremor: a five-year experience. J Neurosurg 1998, 88:1044-1049.
11. Mathieu D, Kondziolka D, Niranjan A, Flickinger J, Lunsford LD: Gamma knife thalamotomy for multiple sclerosis tremor. Surg Neurol 2007, 68:394-399.
12. Report of the American Society for Therapeutic Radiology and Oncology Working Group on the scope of radiation oncology (SCOPE). Int J Radiat Oncol Biol Phys 2002, 54:317-326.
13. Association NMAaNRN: (no title provided): NWT Registered Nurses Association, 1994, p supra note 75.
14. CMA Policy: Scopes of practice, 2001.
15. Barnett GH, Linskey ME, Adler JR, Cozzens JW, Friedman WA, Heilbrun MP, Lunsford LD, Schulder M, Sloan AE: Stereotactic radiosurgery--an organized neurosurgery-sanctioned definition. J Neurosurg 2007, 106:1-5.
16. Lamba M, Breneman JC, Warnick RE: Evaluation of image-guided positioning for frameless intracranial radiosurgery. Int J Radiat Oncol Biol Phys 2009, 74:913-919.
17. Kamath R, Ryken TC, Meeks SL, Pennington EC, Ritchie J, Buatti JM: Initial clinical experience with frameless radiosurgery for patients with intracranial metastases. Int J Radiat Oncol Biol Phys 2005, 61:1467-1472.
18. Nishizaki T, Saito K, Jimi Y, Harada N, Kajiwara K, Nomura S, Ishihara H, Yoshikawa K, Yoneda H, Suzuki M, Gibbs IC: The role of cyberknife radiosurgery/radiotherapy for brain metastases of multiple or large-size tumors. Minim Invasive Neurosurg 2006, 49:203-209.
19. Shimamoto S, Inoue T, Shiomi H, Sumida I, Yamada Y, Tanaka E: CyberKnife stereotactic irradiation for metastatic brain tumors. Radiat Med 2002, 20:299-304.
20. Wowra B, Muacevic A, Tonn JC: Quality of radiosurgery for single brain metastases with respect to treatment technology: a matched-pair analysis. J Neurooncol 2009.
21. Hara W, Tran P, Li G, Su Z, Puataweepong P, Adler JR, Jr., Soltys SG, Chang SD, Gibbs IC: Cyberknife for brain metastases of malignant melanoma and renal cell carcinoma. Neurosurgery 2009, 64:A26-32.
22. Guckenberger M, Baier K, Guenther I, Richter A, Wilbert J, Sauer O, Vordermark D, Flentje M: Reliability of the bony anatomy in image-guided stereotactic radiotherapy of brain metastases. Int J Radiat Oncol Biol Phys 2007, 69:294-301.
23. Masi L, Casamassima F, Polli C, Menichelli C, Bonucci I, Cavedon C: Cone beam CT image guidance for intracranial stereotactic treatments: comparison with a frame guided set-up. Int J Radiat Oncol Biol Phys 2008, 71:926-933.