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# The Canadian Radiosurgery Society Meeting

## ABSTRACTS

*Tremblant, Quebec  
February 29 - March 1, 2008*

Can. J. Neurol. Sci. 2008; 35:386-396

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Over two cold days in Tremblant, more than 85 registrants met for the 3rd meeting of the Canadian Radiosurgery Society (CaRS). Attendees came from St-Johns Newfoundland, New South Wales Australia and the 17,504 kilometers in between. As usual, attendees were a mix of neurosurgeons, radiation oncologists, medical physicists and support staff.

Thanks to support from the major equipment manufacturers as well as a provider of equipment financing solutions, the CaRS was able to invite three distinguished keynote speakers. Professor Douglas Kondziolka returned to his native land to share his considerable experience in interpreting the imaging of brain metastases patients treated with radiosurgery as well as his expertise in treating acoustic neuromas. Professor Yin, now at Duke University, talked on the future of frameless radiosurgery as well as the technical aspects of spine radiosurgery. Dr Milker-Zabel gave a thorough review of the management of meningiomas, including the use of fractionated stereotactic radiotherapy (FSRT) – an approach for which the University of Heidelberg is well regarded. Dr Milker-Zabel was also

able to give a counterpoint to the debate of radiosurgery vs. FSRT for acoustic neuromas.

Nineteen abstracts were presented during 3 oral sessions and, for the first time, 7 abstracts were presented in a poster session. Two of the abstracts were proposals for clinical trials – a randomized comparison of stereotactic radiosurgery vs. deafferenting surgery for trigeminal neuralgia and a randomized trial of tumor bed radiosurgery for single resected brain metastases. Both topics were felt to be pertinent and timely. The tumor bed radiosurgery trial is to be brought to the National Cancer Institute of Canada (NCIC) and it is hoped that the launch of CaRS's first trial will be announced before the next meeting.

At the end of the meeting, there was no doubt as to the viability of the society as radiosurgery centers multiply across the country – next to join the community: Quebec City and St-John's. It was agreed that the society would reconvene in St-John's Newfoundland in 2009-2010.

*David Roberge  
2008 Meeting Director*

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### Session 1 – 10:00 *Oral Papers*

#### COMPLICATIONS OF GAMMA KNIFE RADIOSURGERY

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*Introduction:* Gamma Knife Radiosurgery (GKRS) is available in Canada in Winnipeg, Toronto, and Sherbrooke. Radiosurgery (RS) is not without risk; the delivery of high dose radiation in close proximity to vital neural structures risks radiation injury. There are also risks of incomplete RS administration due to physical constraints of the apparatus and/or patient factors. We examined these events in Toronto and Sherbrooke.

*Materials and Methods:* Adverse events were graded for severity according to the CTC v3.0. In Toronto, a prospectively maintained database was searched for treatment related adverse events. Data on incomplete administrations of radiosurgery were also retrieved. In Sherbrooke, a retrospective chart review was conducted in order to acquire these data.

*Results:* 973 patients treated with GKRS to August 1, 2007 in Toronto and Sherbrooke were studied. Although the vast majority of patients tolerated treatment well, 19 (2%) suffered anxiety, syncopal, or vasovagal episodes. Frame instability was seen in 6 patients which resulted in incomplete administration of RS in 3 patients. Treatments were not completed in nine more patients due to collisions, disease progression, and physical space constraints. The overall rate of incomplete administration was thus 1.2%. Two patients suffered acute coronary events during treatment. Pain was a delayed complication with headaches in 8 patients, all with intracranial tumors, and severe facial pain in 9 patients. Motor deficits, either central or peripheral, were seen in 11 patients, with ataxia from radiation induced edema in 4. One patient experienced facial weakness after treatment of a vestibular schwannoma. Four

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patients required shunting for hydrocephalus, and 16 patients suffered from delayed seizures.

*Conclusions:* GK has provided patients with a minimally invasive method for treatment of a variety of intracranial diseases, both benign and malignant. However such treatment is not risk free, and a small proportion of patients experience adverse events.

#### Session 1 – 10:10 *Oral Papers*

### OUTCOMES FOLLOWING STEREOTACTIC RADIOSURGERY FOR BRAIN METASTASIS: DOES THE SCHEDULE OF WHOLE-BRAIN RADIOTHERAPY MATTER?

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*Background:* A standard treatment plan for patients with limited brain metastases is stereotactic radiosurgery (SRS) combined with whole-brain radiotherapy (WBRT). When used without SRS, shorter courses of WBRT have been shown to produce equivalent survival outcomes but have not been tested in combination with SRS — a setting where the main purpose is prevention of new metastases.

*Methods:* This retrospective review included patients treated at our institution with SRS and adjuvant WBRT. The dose schedule of WBRT was dependant on physician preference. Patients were treated at the Montreal General Hospital from April 1999 to July 2006. All outcomes were calculated actuarially. Curve comparisons were done following the logrank method.

*Results:* 67 patients were identified, 39% male and 61% female. The median age was 59. The most common primary malignancies were lung (63%) and breast (18%). A median of 1 (mean 1.6) lesion per patient was treated with SRS. 37 patients received short-course WBRT (typically 20 Gy in 5 fractions, BED  $Gy_{10} < 30$ ) and 30 patients were treated with a more standard fractionation (typically 30 Gy in 10 fractions, BED  $Gy_{10} > 30$ ). 83.6% of patients have died. Median follow-up for living patients is 17.4 months. 19.8%, 38.6% and 38.6% of patients developed new brain metastases following short course radiation vs. 35.4%, 42.6% and 42.6% of patients receiving the higher BED schedules at 6 months, 1 year, and 2 years ( $P=0.56$ ). Overall in-brain failure was 27.3%, 65.4% and 82.7% in the short hypofractionated group vs. 35.4%, 48.3% and 48.3% following more standard WBRT at 6 months, 1 year and 2 years ( $P=0.57$ ). Median overall survival was 8.9 months and 12.6 months for the short and longer fractionation regimens, respectively ( $p=0.8$ ).

*Conclusion:* In our dataset, the choice of fractionation scheme of WBRT was not shown to impact on the occurrence of new brain metastases. However we remain cautious in using short course radiation in the adjuvant setting.

#### Session 1 – 10:20 *Oral papers*

### STEREOTACTIC BODY RADIOTHERAPY (SBRT) FOR SPINOUS METASTASES: PRELIMINARY EXPERIENCE AT THE UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

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*Purpose:* Spine SBRT dose distributions may inadequately cover 5-25% of the target volume at the tumor-spinal cord interface due to concerns of neural toxicity. Therefore, target BED adjacent to the spinal cord is often less than that achieved with conventional radiotherapy.

*Methods:* We reviewed 38 consecutive patients, 60 metastases, treated from 4/2003 to 8/2006. No margin was applied to the GTV, however, for post-operative cases (15/60) the PTV included residual GTV plus the surgical bed. Local failure was based on symptom progression and/or local tumor growth based on imaging.

*Results:* Median overall survival was 18 months (9-27), 20/38 patients have died, and median follow-up is 8.5 months (0.5-48). The mean and median minimum distance from PTV to the neural contour was 2.1 mm and 1 mm, respectively. For previously irradiated tumors, the median total dose prescribed was 24 Gy (8-30) in 3 fractions (1-5) prescribed to the 60% (46-78%) isodose line. For unirradiated tumors, the median total dose prescribed was 24 Gy (7-30) in 3 fractions (1-5) prescribed to the 64% (44-84%) isodose line. Local progression occurred in 8/60 tumors. The mean and median minimum distance from PTV to neural contour was 0.9 mm and 0.7 mm in those tumors progressed, respectively, and 2.2 mm and 1 mm for those tumors with no progression ( $p=0.02$ ), respectively. In 6/8 failures the distance was <1 mm, and radiographic progression was documented, but not exclusive, at the neural contour-PTV interface. The median time to local failure was 6.5 months (1-22). There was no significant difference in local failure or overall survival between the previously irradiated and unirradiated cohort, respectively.

*Conclusion:* At the neural contour-PTV interface, the steep dose gradient may compromise local control when this distance is < 1 mm. Prior radiotherapy should not preclude patients from this aggressive treatment option.

#### Session 1 – 10:30 *Oral Papers*

### RADIOSURGERY PRACTITIONER ATTITUDES REGARDING THE USE OF STEREOTACTIC RADIOSURGERY ALONE FOR OLIGOMETASTATIC BRAIN METASTASES

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*Introduction:* Cranial oligometastatic disease may be treated with stereotactic radiosurgery alone (SRS-A), but no consensus exists as to when SRS-A would be appropriate.

*Purpose:* To determine which factors SRS practitioners emphasize in choosing SRS-A, and what physician characteristics associate with recommending SRS-A for >5metastases.

*Materials/Methods:* All physicians attending ISRS 2007 were asked to complete a questionnaire ranking 14 clinical factors on a 5-

point Likert-type scale (1=none; 5=very strong) to determine how much each factor might influence a decision to recommend SRS-A for brain metastases. Results were condensed into a single dichotomous outcome variable of “influential” (4-5) vs. all others (1-3). The physician characteristics of practitioners willing to use SRS-A for >5 metastases was assessed (univariate:  $\chi^2$ ; multivariate (MVA): logistic regression).

**Results:** 95 completed surveys were collected. 60.7% were academicians; 53.7% were neurosurgeons; 73.7% had >5 years of SRS experience; and 65.3% treated >30 cases brain metastases/year with SRS. Most influential were KPS (78%), presence/absence of mass effect (76%) and systemic disease control (63%). Also important were metastases related neurologic symptoms (56%) or unrelated neurologic disease (51%), metastases location (55%), size (45%), histopathology (40%) and radiographic appearance (20%), patient age (50%) and social situation (21%), and availability of additional useful chemotherapy (38%). 55% of respondents considered treating > 5 metastases “reasonable”, including 77.1% of private practitioners vs. 44.4% of academicians ( $\chi^2$ ,  $p=0.002$ ), 68.6% of neurosurgeons vs. 38.6% of radiation oncologists ( $p=0.003$ ), and 72% of Gamma Knife users vs. 34.9% of linac users ( $p=0.002$ ). By MVA, neurosurgeons ( $p=0.033$ ) and Gamma Knife users ( $p=0.002$ ) were significantly more likely to treat >5 metastases with SRS-A.

**Conclusion:** No clear consensus exists for how many metastases are reasonable to treat with SRS-A or what factors should be used to assess candidate patients. Further studies should confirm these findings and assess attitudes of referring physicians.

#### Session 1 – 10:40 *Oral Papers*

##### FRACTIONATED STEREOTACTIC TREATMENT OF CHOROIDAL MELANOMA

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**Purpose:** Choroidal melanoma tumors in the juxtapapillary location (within 2 mm of the optic nerve) are challenging to treat due to the proximity, and often abutment, of the tumor to the optic nerve head. The purpose of this study is to report the efficacy and complications for such patients, treated with fractionated stereotactic radiotherapy (SRT).

**Methods:** We performed a retrospective review of 64 consecutive patients with juxtapapillary choroidal melanoma treated with SRT between 1998-2006. The prescribed radiation dose was 70 Gy in 5 fractions delivered over 10 days, and the median prescription isodose 95% (90-100%). The PTV consisted of the GTV plus a 1 mm margin. The primary outcome measure was local control. No patient was lost to followup.

**Results:** The median age was 63 years, and the median follow-up 26 months. All tumors were located in the juxtapapillary location with a median of 0 mm from the edge of the optic nerve. Median tumor height and maximum tumor diameter was 4.2 mm and 9.8 mm, respectively. Post-treatment, three patients developed local (in-field) tumor recurrence, and 8 patients progressed systemically.

Actuarial rates of local tumor control, metastases, and survival at 26 months were 94%, 12%, and 94%, respectively. Rates of radiation induced neovascular glaucoma, cataract, retinopathy, and optic neuropathy at 26 months were 28%, 45%, 80%, and 52%, respectively. The rate of cataract and neovascular glaucoma was found significantly greater ( $p=0.006$  and  $p=0.004$ , respectively) when the lens dose exceeded 10 Gy (BED=20 Gy<sup>2</sup>). Enucleation was necessary in 3/7 patients due to tumor recurrence, and for 4/7 patients due to painful neovascular glaucoma.

**Conclusion:** We have observed acceptable rates of local control and ocular toxicities with SRT. Future treatment planning will aim to minimize the lens dose below 10 Gy, with the aim of reducing the risk of the potentially devastating complication of neovascular glaucoma.

#### 12:30 *Functional Radiosurgery*

##### PROPOSAL FOR A MULTICENTRE RANDOMIZED CONTROLLED TRIAL OF STEREOTACTIC RADIOSURGERY VS. CONVENTIONAL DEAFFERENTING SURGERY FOR TRIGEMINAL NEURALGIA

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Typical trigeminal neuralgia in the elderly is conventionally treated with deafferenting surgery. Such same day percutaneous rhizotomies are well tolerated and provide up to several years of pain relief. Stereotactic radiosurgery (SRS) has also been proposed as an alternative, however no controlled clinical trial has yet been performed. With the advent of multiple radiosurgical centres in Canada, we have the opportunity to investigate the question: Which procedure, conventional deafferenting surgery or SRS, provides longer pain-free status in typical trigeminal neuralgia?

We propose a multicentre prospective randomized clinical trial with independent observers assessing outcome of SRS vs. surgical percutaneous rhizotomy. Because the focus of this trial is to compare SRS to the best available surgical alternative in each participating centre, surgical technique will not be dictated. SRS will, however, be offered in a standard fashion with the same targeting and dosing of the trigeminal root entry zone. The primary outcome measure will be time to resumption of medications, or pain-free interval. Kaplan-Meier methods will be used to compare groups in regards to medication-free survival. Secondary outcome measures may include time to re-operation, adverse effects, Brief Pain Inventory, Hospital Anxiety and Depression Scale, Quality of Life measures, McGill Pain Questionnaire, objective sensory examinations of the face, and economic analysis of the costs of treatment.

The presentation will provide details, inclusion and exclusion criteria, estimated numbers of cases required to achieve clinical and statistical relevance and timelines to complete accrual. These will influence inclusion of different populations of patients; hence this will be the major aim of our discussion. If there is sufficient interest and agreement among centres an application to the CIHR Clinical Trials committee will be submitted.

12:40 *Functional Radiosurgery***GAMMA KNIFE THALAMOTOMY FOR MULTIPLE SCLEROSIS TREMOR**

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**Background:** Some patients with multiple sclerosis suffer from disabling tremor. Improvement with medical treatment is modest, at best. Stereotactic surgery targeting the v.i.m. nucleus of the thalamus has been successful in alleviating multiple sclerosis tremor. Gamma knife radiosurgery represents a minimally invasive alternative to radiofrequency lesioning and deep brain stimulation that can provide improvement in patients suffering from essential and parkinsonian tremor. We reviewed our experience with gamma knife thalamotomy in the management of six consecutive patients suffering from disabling multiple sclerosis tremor.

**Methods:** The median age at the time of radiosurgery was 46 years (range, 31 to 57 years). Intention tremor had been present for a median of three years (range 8 months to 12 years). One 4-mm isocenter was used to deliver a median maximum dose of 140 Gy (range 130 to 150 Gy) to the v.i.m. nucleus of the thalamus opposite the side of the most disabling tremor. Clinical outcome was assessed using the Fahn-Tolosa-Marin scale.

**Results:** The median follow-up was 27.5 months (range, 5 to 46 months). All patients experienced improvement in tremor after a median latency period of 2.5 months. More improvement was noted in tremor amplitude than in writing and drawing ability. In four patients, the tremor reduction led to functional improvement. One patient suffered from transient contralateral hemiparesis, which resolved after brief corticosteroid administration. No other complication was seen.

**Conclusion:** Gamma knife radiosurgical thalamotomy is effective as a minimally-invasive alternative to stereotactic surgery for the palliative treatment of disabling multiple sclerosis tremor.

Session 2 – 13:30 *Oral Papers***COMPARISON OF CONFORMAL STEREOTACTIC RADIOTHERAPY (CSRT) AND INTENSITY MODULATED STEREOTACTIC RADIOTHERAPY (IMSRT) FOR SKULL BASE MENINGIOMA: A TREATMENT PLANNING STUDY**

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**Purpose:** To assess the potential benefits and limitations of IMRST in the treatment of skull base meningioma and to assess the role of dosimetric parameters in the qualification of competing treatment plans.

**Methods:** CT simulation images and MRI Fusion were used for delineation of target volumes and organs at risk for five skull base meningioma cases (3 cavernous sinus, 1 suprasellar and 1 olfactory groove). Treatment plans were generated for 3DCSRT, IMRST (7-9 fields step and shoot) and Helical Tomotherapy (HT). Plans used for

this comparison were deemed acceptable by an expert radiation oncologist. The conformity index (CI), homogeneity index (HI), target coverage index (Cov.I), the maximum dose to each organ at risk and the critical organ scoring index (COSI) were used to assess the quality of each plan in terms of PTV coverage and organ at risk sparing.

**Results:** The mean PTV was 17.1 cm<sup>3</sup> (range 7.4-24.4 cm<sup>3</sup>). Treatment planning with 3DCSRT showed better CI and Cov.I than planning with IMRST techniques with P values of 0.01 and 0.0001, respectively. No significant differences were seen between the 2 IMSRT techniques. In contrast, the H.I was significantly better with IMSRT techniques (p= 0.0001). HT achieved the lowest maximum dose to optic chiasm (p=0.025) than 3DCSRT with a mean difference of 3.3 Gy. Regardless of the technique, the maximum dose to optic nerves, brainstem and the COSI for all critical structures showed no statistically significant difference.

**Conclusions:** The use of IMRST showed no significant improvement in dose distribution over 3DCSRT for skull base meningiomas. COSI revealed not to be a discriminatory tool in the evaluation of competing plans, although additional cases will be analyzed. Correlation of this dosimetric study to an independent clinical evaluation is needed.

Session 2 – 13:40 *Oral Papers***DOSIMETRIC COMPARISON OF INTENSITY-MODULATED RADIOTHERAPY AND HELICAL TOMOTHERAPY FOR MULTIPLE INTRACRANIAL METASTASES**

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**Purpose:** The treatment of multiple brain metastases with traditional multi-isocentre stereotactic techniques is time consuming and does not allow the optimization of dose delivery considering the contribution from all lesions treated. Single fraction, single-isocentre, intensity-modulated radiosurgery (IMRS) and helical tomotherapy (HT) are techniques that could address these limitations through the simultaneous optimized planning and treatment of multiple lesions. We sought to compare the treatment of 3-6 intracranial metastases using these two techniques.

**Methods:** Dose plans for 10 patients with 3-6 brain metastases treated at UCSD with IMRS will be re-planned with HT. The first patient comparison has been completed as proof of principle. The illustrative patient had four brain metastases (one left cerebellar, three frontal) with a total PTV volume of 15.6 cm<sup>3</sup>. The dose for the original IMRS plan was 2000 cGy in one fraction. Comparisons are based on coverage of the PTV, dose volume histograms for organs at risk, integral dose to normal brain, maximum dose to prescription dose ratio (MDPD), prescription isodose volume to tumor volume (PITV), and treatment time. The normal brain volume was 1483.5 cm<sup>3</sup> for the IMRS plan and 1444.2 cm<sup>3</sup> for the HT plan due to priorities assigned to decrease dose to brainstem.

**Results:** The sliding-window IMRS plan (Varian Trilogy linear accelerator with 120 leaf multi-leaf collimator and Eclipse planning system) consisted of a single-isocentre, single fraction plan using 10

noncoplanar fields and frameless optical guidance. HT immobilization for minimally invasive stereotaxis consists of a thermoplastic S-frame and pre-treatment MVCT is used for image-guidance. The comparison HT plan utilized a field width of 2.5 cm with a pitch of 0.172 and a modulation factor of 2.4. The minimum/maximum PTV coverage for IMRS was 91%/116% and for HT was 98%/108%. The MDPD for IMRS and HT was 1.2 and 1.1, respectively. The PITV for IMRS and HT was 1.4 and 1.0, respectively. The median and mean doses to brain were 315 cGy and 409 cGy for IMRS and 287 cGy and 414 cGy for HT. The integral dose to brain was 5.9 Gy-kg for both plans. The maximum doses (cGy) to organs at risk for IMRS and HT, respectively, are as follows: brainstem (506, 550), optic chiasm (339, 218), left eye (73, 118), right eye (64, 329), left optic nerve (109, 143), and right optic nerve (273, 136). The total estimated beam-on treatment times were 30 minutes for IMRS and 48.5 minutes for HT.

**Conclusions:** In the proof of principle case conformality and homogeneity of target coverage were slightly better with HT, and sparing of organs at risk was slightly improved with IMRS. The overall integral dose to normal brain was the same. Overall treatment time was estimated to be less for IMRS. The full dataset for the 10 patients will be presented and additional comparisons with traditional radiosurgery (gamma knife) are planned.

#### Session 2 – 13:50 *Oral Papers*

##### **FEASIBILITY OF NON-COPLANAR MULTIARC IMRS USING HELICAL TOMOTHERAPY FOR THE TREATMENT OF INTRACRANIAL LESIONS**

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Helical tomotherapy (HT) combines linear accelerator-based intensity modulated fan-beam radiotherapy delivery with megavoltage computerized tomography (MVCT) technology for patient set-up verification. HT is able to deliver highly conformal dose distributions however its current design prohibits non-coplanar delivery which is fundamental for achieving acceptable radiosurgical isodose distributions. We propose a novel means of attaining non-coplanar multiarc HT delivery by administering treatments using multiple fixed head positions. This study is a dosimetric comparison of HT-based coplanar IMRT using a single head position versus non-coplanar multiarc IMRT using multiple fixed head positions for the treatment of intracranial lesions. An anthropomorphic (Rando) phantom was used in this study with a simulated medium-size intracranial spherical target (14.13 cm<sup>3</sup>). The head phantom was immobilized using a standard thermoplastic head mask and a custom made head rest which allows variable head positions in the axial plane. The head phantom was scanned on a kVCT simulator (2mm slice thickness) in the resting position as well as in the maximal neck extension and flexion positions. An optimized treatment plan was obtained for each head position using the HT inverse planning algorithm. Prescriptions were set in the HT software so that the prescription dose was to be delivered to 99% of the PTV. Planning parameters used for the HT plans were fan beam thickness: 1.05 cm; helical pitch: 0.3; modulation factor: 4.0; fine calculation grid. GAF chromic film was then placed in the sagittal and axial planes of the target and three serial treatment fractions were delivered to the phantom head for the resting head position

(coplanar IMRS). The phantom head was also treated serially in all three separate head positions (non-coplanar multiarc IMRS). The resulting deliveries were verified and compared with computerized GAF film dosimetry analysis with respect to their measured dose distribution. We report on these comparisons and present the conclusions of this feasibility study including an analysis of logistical and technical difficulties.

#### Session 2 – 14:00 *Oral Papers*

##### **3T MRI FOR GAMMA KNIFE® RADIOSURGERY TREATMENT PLANNING: GEOMETRIC ACCURACY**

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**Objectives:** Magnetic Resonance Imaging (MRI) is central to Gamma Knife® (GK) radiosurgery (RS) treatment planning. While higher field strength improves signal, increased magnetic susceptibility may introduce geometric inaccuracies, leading to compromised GK delivery. Our objective is to explore the geometric accuracy of 3T MRI for GK RS.

**Methods:** Twenty-six GK RS patients were enrolled on a prospective clinical trial and received the following imaging studies: 1) CT, 2) 1.5T MRI (GE HD: 3D T1-FSPGR and 3D T2-FRFSE), and 3) 3T MRI (GE HDx: 3D T1-FSPGR and 3D T2-FRFSE). TOPAS, a geometric phantom/software designed for GK, was utilized. For 17 cases, phantom imaging was performed on 3T prior to patient imaging. All images were corrected for known 3D gradient nonlinearities. Geometric accuracy in phantom was evaluated using stereotactic reference deviations (GammaPlan®) and internal geometry deviations (TOPAS). Geometric accuracy in patients was compared between 3T and 1.5T using stereotactic reference deviations for all 26 patients, and displacement of anatomic landmark (cochleae and semicircular canals) relative to CT for 8 patients.

**Results:** T1-FSPGR on 3T yielded similar mean (SD) stereotactic reference deviations [0.5(0.2)mm] compared to 1.5T [0.6(0.1)mm] for all 26 patients. Subsequent to 3T hardware update, T2-FRFSE also yielded comparable stereotactic reference deviations between 3T [0.4(0.1)mm] and 1.5T [0.6(0.1)mm] in 21 patients. The mean stereotactic reference deviations correlated well between phantom and patient for both T1-FSPGR (R=0.81) and T2-FRFSE (R=0.87). The mean deviations of phantom internal geometric reference in the axial plane at 3T were 0.4(SD=0.1)mm and 0.3(SD=0.1)mm for T1-FSPGR and T2-FRFSE respectively. The difference between mean anatomic landmark displacement at 3T and 1.5T (relative to CT) was 0.1(SD=0.3)mm.

**Conclusions:** Geometric accuracy of stereotactic references in 3T MRI is comparable to 1.5T MRI for GK RS planning. Internal geometric accuracy at 3T is established in phantom and patients under the imaging conditions investigated.

Session 2 – 14:10 *Oral Papers***A DIGITAL METHOD OF MEASURING THE ACCURACY OF STEREOTACTIC RADIATION BEAMS AND ALIGNMENT OF SETUP LASERS**

D.P. Spencer, and I.A. Nygren

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Like many other centres we use precision lasers to align patients for SRS or FSRT treatment. Safety and efficacy of treatment requires accurate alignment of the radiation field and the lasers. The Winston-Lutz test, using film, was used by the manufacturer to set up our Novalis machine. and we use it weekly or before each SRS patient whichever is more frequent. Detection of errors greater than or equal to 0.25 mm, or 250 microns is possible.

We have developed a method of direct digital detection of both X-Rays and visible light with one imaging device. We use a digital photodiode array to measure the alignment of the lasers with the radiation field. We also measure the drift of the radiation field with rotation of the collimator and gantry with an accuracy of better than 50 microns. Our results show that the collimator rotation produces a radius of 230 microns, the gantry sag was +/- 375 microns and the head tilt is 100 microns.

The array with our in-house software serves as an excellent QA device and could potentially be used to improve the alignment of the components of the system.

Session 2 – 14:20 *Oral Papers***TARGET VOLUME TREATMENT MARGIN FOR THE CBCT-BASED INTRACRANIAL STEREOTACTIC RADIOSURGERY/RADIOTHERAPY**M. Heydarian<sup>1</sup>, M. van Prooijen, M. Islam, G. Tsui, N. Laperriere<sup>2</sup>

Dept. Radiation Physics, Princess Margaret Hospital, Toronto, Ontario<sup>1</sup>, Dept. Radiation Oncology, Princess Margaret Hospital, Toronto, Ontario<sup>2</sup>

*Purpose:* To redefine the planning target volume (PTV) margins for intracranial stereotactic radiosurgery (SRS) and stereotactic radiotherapy (SRT) techniques following the introduction of kilovoltage Cone Beam CT (CBCT) image guidance for treatment localisation.

*Methods and Materials:* CBCT image guidance on an Elekta "Synergy S" linac was used to determine the setup error and consequently PTV margin for SRS/SRT patients. Ten consecutive SRT patients receiving daily CBCT images before and after treatment have been chosen for this study. Patients were immobilized using the GTC relocatable frame using our standard SRT protocol. Each patient received 25 to 35 treatment fractions. Acquired CBCT images were co-registered with the patients' planning CT images using the grey value algorithm. Patients intrafraction motions were also quantified by comparing pre- and post-treatment CBCT data. Random and systematic errors were calculated and their respective standard deviations ( $\sigma$  and  $\Sigma$ ) were added in quadrature. The PTV margin was calculated using the  $2.5\Sigma+0.7\sigma$  formula.

*Results:* The co-registration results have generally been in good agreement with the actual patient setup values, indicated by our

standard setup and depth helmet readings. The group systematic setup error (overall mean) was 0.20 mm with standard deviation of 0.12 mm. The random errors standard deviation was 0.33 mm. The CBCT-based PTV margin calculated using the above formula was 0.54 mm, compared with our conventional SRT PTV margin of 1.5 mm.

*Conclusion:* CBCT image guidance is an accurate and useful tool for patient setup and verification in SRS and SRT techniques. We have shown that, using image guidance, a sub-millimetre combined targeting accuracy is achievable and therefore the PTV margin can be reduced accordingly. Using this image guidance strategy, we have now replaced the invasive radiosurgery frame with a non-invasive relocatable frame in our clinic for single fraction radiosurgery without compromising setup precision and immobilization.

Discussion *Protocol Proposals***POST-OPERATIVE RADIOSURGERY TO THE TUMOR BED FOLLOWING RESECTION OF A SINGLE METASTASIS: PROPOSAL FOR A RANDOMIZED CLINICAL TRIAL**

D. Roberge

Department of Radiation Oncology, McGill University

Despite whole-brain radiotherapy, the most common site of intracranial recurrence following resection of a single parenchymal metastasis is the resection margin. Brain metastases are the most common malignancy treated with radiosurgery and there is currently no high level evidence supporting the use of tumor bed radiosurgery. In a survey of 12 2006 CaRS attendees from 6 Canadian radiosurgery centers, interest was seen for a prospective trial.

A potential trial would randomize approximately 70 patients to whole-brain radiotherapy (30 Gy in 10 fractions) followed or not by a 10 Gy boost to the margin or the tumor cavity. This would provide an 80% power to show a decrease from 30% recurrence to 10% recurrence. Accrual on a reasonable timetable should be possible considering the large patient pool (approximately 300/annum according to the respondents). This and alternate schemas will be discussed at the meeting before making plans to approach a granting agency.

Session 3 – 9:40 *Oral Papers***A REVIEW OF STEREOTACTIC RADIOTHERAPY OR STEREOTACTIC RADIOSURGERY AT THE TOM BAKER CANCER CENTRE FOR ACOUSTIC NEUROMAS**Z. Gabos<sup>1</sup>, E. Yan<sup>1</sup>, H. Lau<sup>1</sup>, A. Chan<sup>1</sup>, R. Manthey<sup>1</sup>, D. Spencer<sup>2</sup>, C. Newcomb<sup>2</sup>

<sup>1</sup>Radiation Oncology and <sup>2</sup>Medical Physics, Tom Baker Cancer Centre, Calgary, Alberta

*Background:* Radiation therapy is an accepted treatment option for patients with acoustic neuromas, either as primary treatment or for disease recurrence after surgery. Treatment can be delivered in a single fraction, stereotactic radiosurgery (SRS), or it can be conventionally fractionated.

*Objectives:* To review the clinical and treatment characteristics of all acoustic neuroma cases treated by fractionated stereotactic

radiotherapy (FSRT) or single fraction radiosurgery at the Tom Baker Cancer Centre (TBCC).

**Methods:** Since 2001, 16 patients have been treated with SRS, and 13 patients have been treated with FSRT for acoustic neuromas. Clinical data, imaging studies and archived treatment plans were accessed and reviewed from the patient database.

**Results:** Single fraction stereotactic radiosurgery was given to 8/16 patients as primary treatment while 8/16 patients received it for disease progression after surgical resection. The mean prescribed dose was 13.5 Gy (range 12-17.5 Gy). Mean tumor volume was 2.49 cm<sup>3</sup>. Nine patients received FSRT as primary treatment, and 4/13 patients received it for disease progression after surgical resection. All patients were treated in 25 daily fractions, with prescription doses of 45 Gy (2/13 patients) or 50 Gy (11/13 patients).

Mean tumor volume was 5.63 cm<sup>3</sup>. With a median follow-up of 13.0 months, two patients had evidence of disease progression in the SRS group. None of the patients treated by FSRT have progressed. There was no difference in treatment-related toxicities between the two treatment regimes.

**Conclusions:** Stereotactic radiosurgery or FSRT is an effective and safe treatment option for patients with acoustic neuromas. Further long-term follow-up will be required to assess long-term local control and toxicity.

#### Session 3 – 9:50 *Oral Papers*

##### CEREBRAL EDEMA AFTER GAMMA KNIFE TREATMENT FOR MENINGIOMAS

*D. Fewer, M. West, A. Kaufman, G. Schroeder*

Sections of Neurosurgery and Radiation Oncology, University of Manitoba, MB

Between November 2003 and March 2007, 685 patients have had Gamma Knife treatment of which 61 had meningiomas. 37 were parasagittal, convexity or anterior skull base and 32 were cavernous, CPA or other posterior fossa locations. 9/37 and 16/32 had no prior surgery. Of those with a tissue diagnosis, 19 were benign, 11 were atypical and 3 were malignant. All of the latter died from their disease in this follow up period. 12 patients developed significant, new edema in the early post radiation period of which 8 required prolonged steroid treatment. Historically and also in our series, none of the tumors in the cavernous sinus, CPA or other posterior fossa sites developed this complication. The significant incidence is therefore 12/37 or 33% of the supratentorial group. This finding has significant implications with regard to informed consent, especially in cases where stereotactic radiation is being considered as primary treatment for tumors in this location.

#### Session 3 – 10:00 *Oral Papers*

##### NON-SURGICAL MANAGEMENT OF MENINGIOMAS INVOLVING THE CAVERNOUS SINUS

*R.J Smee, J.R Williams, M. Schneider*

Department of Radiation Oncology, The Prince of Wales Cancer Centre, High Street, Randwick NSW.

**Objectives:** An appropriate management option for meningiomas is resection, however involvement of the cavernous

sinus usually confers non-resectability. This review will evaluate a single centre's experience with treatment of this type of tumour.

**Methods:** The meningioma database at The Prince of Wales Cancer Centre was sourced to determine those patients treated by any form of radiotherapy between 1990 to December 2004, n=283. The eligibility feature was involvement of the cavernous sinus, not necessarily origin. All patients had clinically progressive features, and/or imaging defined enlarging tumour. These characteristics defined 147 patients of whom 90 had radiotherapy as part of initial treatment, or 57 who had it at the onset of progressive disease. This population covers those treated by conventional treatment, stereotactic radiosurgery (SRS), and stereotactic fractionated (SRT) approaches. The decision to use SRS versus SRT was based on the volume of the meningiomas (median 5.65cc versus 13.4cc respectively) and/or proximity to optic chiasm.

**Results:** All patients had clinical features, or imaging demonstrating progressive disease, that warranted treatment. The age range was 7 – 82 years with 110 (75%) females. Fractionated treatment for 80 patients usually consisted of 50.4Gy in 28 fractions, for 56 radiosurgery patients it was 14Gy, 10 patients had conventional radiotherapy. Median follow up is 39.5 months with a local control figure of 95%. The majority of patients had symptomatic improvement, neurological improvement more likely occurred where there was less than six months duration of dominant features. Neurological complications occurred in less than 5% of patients. No second tumours have yet been recorded in this population.

**Conclusion:** Meningiomas involving the cavernous sinus can rarely be completely resected. Stereotactic irradiation offers a high likelihood of control, and should be considered as an alternative treatment.

#### Session 3 – 10:10 *Oral Papers*

##### MULTIMODALITY CARE OF OCCIPITAL LOBE ARTERIOVENOUS MALFORMATIONS (AVMS): OUTCOME OF A PROSPECTIVE SERIES OF 134 PATIENTS

*A. Dehdashti, L. Thines, M. Tymianski<sup>1</sup>, R. Willinsky, K. terBrugge, C. Wallace<sup>1</sup>, M. Schwartz<sup>2</sup>*

Division of Neurosurgery, Toronto Western Hospital, Toronto, Ontario<sup>1</sup>, Division of Neurosurgery, Sunnybrook Health Sciences Centre, Toronto, Ontario<sup>2</sup>

**Objective:** To study the outcome of multimodality management of occipital AVMs, challenging to treat because of their proximity to optic radiations and visual cortex.

**Methods:** A review of the prospective data base of the University of Toronto Brain Vascular Malformation Study Group identified 134 patients with occipital AVMs treated between 1985 and 2007 and correlated patient characteristics, mode of presentation and AVM morphology with outcomes.

**Results:** 125 patients presented with one or more symptoms, including headache (50), seizure (43), visual deficit (33) and hemorrhage (32). Visual deficit was associated with hemorrhage (p<0.002). Mean follow-up was 4.78 years. 12 patients were lost to follow-up. 47 patients received no treatment. 2/14 untreated patients with visual deficit improved and 2 worsened. During follow-up,

3/47 bled, 2 developing a new visual deficit. 2 patients died of causes unrelated to their AVM. 87 patients were treated with 1 or more modalities. 34/36 patients treated with surgery were cured, as compared with 22/28 and 4/53 treated with radiosurgery (SRS) and embolization respectively. The overall cure rate utilizing multiple modalities was 76%. 7/32 presenting with visual deficit improved and 2/32 worsened. 14/87 had a new, usually minor, deficit. Two patients rebled after partial treatment and three died of their treatment. Neurological morbidity was higher in the treatment group than in the untreated group ( $p=0.005$ ), but mortality was not statistically different. Visual deficit improvement was more frequent in the treated group ( $p=0.02$ ). The subgroup of 45 patients with unruptured AVMs had seven with new deficits, of whom three had new visual deficits. There was no mortality.

**Conclusions:** For occipital AVMs, treatment yields better visual outcomes than observation, but there is a risk of a new neurological deficit, usually minor.

#### Session 3 – 10:20 *Oral Papers*

##### **A REVIEW OF IMAGE-GUIDED FRAMELESS STEREOTACTIC RADIOTHERAPY AT THE TOM BAKER CANCER CENTRE FOR SPINE TUMORS**

Z. Gabos<sup>1</sup>, E. Yan<sup>1</sup>, H. Lau<sup>1</sup>, A. Chan<sup>1</sup>, R. Manthey<sup>1</sup>, D. Spencer<sup>2</sup>, C. Newcomb<sup>2</sup>

Radiation Oncology<sup>1</sup> and Medical Physics<sup>2</sup>, Tom Baker Cancer Centre, Calgary, Alberta

**Background:** Radiation therapy has been used in the treatment of spine tumors in an adjuvant setting to decrease risk of local recurrence, as well as for primary treatment in recurrent or unresectable tumors. The Novalis® stereotactic system has been designed to treat both cranial and extra-cranial sites, including spine tumors, with precision guided radiation. It has been used at the Tom Baker Cancer Centre (TBCC) in the treatment of spine tumors.

**Objectives:** To review the clinical and treatment characteristics of all spine tumor cases treated by image-guided frameless stereotactic radiotherapy at the TBCC.

**Methods:** Five patients with spine tumors have been treated at the Alberta Radiosurgery Centre since 2005. Clinical data, imaging studies and archived treatment plans were accessed and reviewed from the patient database.

**Results:** Tumor histologies treated included two chordoma, one meningioma, one schwannoma and one hemangioma. All patients had initial surgical resection and were treated with radiation for tumor progression or recurrent disease. Custom body immobilization was used for all patients. The mean prescription dose was 52.7 Gy (range 45 – 68 Gy), using conventional fractionation (1.8-2 Gy/fraction). Maximum spinal cord dose ranged from 44.6 Gy to 52.5 Gy. After a median follow-up 17.8 months, all patients are without evidence of disease progression. There has been no evidence of radiation related spinal cord toxicity.

**Conclusions:** Fractionated stereotactic radiotherapy for spinal cord tumors using the Novalis® stereotactic system is feasible and safe. Further long-term follow-up will be required to assess long-term local control and toxicity.

#### *Poster Exhibit*

##### **GAMMA KNIFE RADIOSURGERY FOR PATIENTS WITH BRAIN METASTASES**

F. Iqbal<sup>1</sup>, G. Schroeder<sup>1</sup>, D. Fewer<sup>2</sup>, A. Kaufmann<sup>2</sup>, M. West<sup>2</sup>

<sup>1</sup>CancerCare Manitoba, University of Manitoba, <sup>2</sup>Department of Neurosurgery, University of Manitoba

**Purpose:** To determine the factors that predict morbidity and survival in patients treated with Gamma Knife stereotactic radiosurgery (SRS) for brain metastases.

**Methods:** 162 patients who underwent Gamma Knife treatment from Nov 13, 2003 to Nov 1, 2006 were reviewed retrospectively, totaling 207 treatments. Seventy-five patients had lung cancer, 38 breast cancer, 18 melanoma, and 31 had other cancers. Patient and disease characteristics, as well as treatment factors (chemotherapy, surgery, whole-brain radiation, as well as SRS dosimetry) were recorded. Physical and neurological side effects were noted, as was time to progression after SRS and survival.

**Results:** The median survival from diagnosis of brain metastases to death was 9.9 months (range 1-53 months). Following treatment, survival was 12.4 months if KPS  $\geq 70$ , 3.6 months if KPS  $< 70$  ( $p < 0.0001$ ); 11.2 months if primary disease was controlled, 8.0 months if uncontrolled; 9.9 months for age  $< 65$ , 11.3 months for age  $\geq 65$ ; 6.8 months if systemic metastases were present, 12.4 months if the brain was the only site of metastases ( $p=0.003$ ). The volume treated averaged 6.6 cc (range 0.125 – 33.7 cc). The maximum single volume was 22.2 cc, with a maximum diameter of 41.3mm. Physical side effects were generally mild if any occurred, with 59% of patients experiencing no acute side effects, 29% experiencing headache, 4% nausea, and 13% miscellaneous other. Neurological side effects were rare, with 2 patients experiencing seizures (one previously had seizures), and one developing a new tremor.

**Conclusions:** Gamma Knife SRS is a well tolerated procedure with rare serious side effects for patients with brain metastases. Survival can be prolonged, particularly if patients are selected carefully.

#### *Poster Exhibit*

##### **PATIENTS' EXPERIENCE WITH GAMMA KNIFE RADIOSURGERY: A QUALITATIVE STUDY**

M. Bernstein<sup>1</sup>, W. Mendonca, M. Cusimano<sup>2</sup>, C. Ménard<sup>3</sup>, H. Sharpe

Division of Neurosurgery Toronto Western Hospital, Toronto, Ontario<sup>1</sup>, Department of Neurosurgery, St. Michaels Hospital, Toronto, Ontario<sup>2</sup>, Dept. Radiation Oncology, Princess Margaret Hospital, Toronto, Ontario<sup>3</sup>

**Background:** A large number of clinical reports have been published on Gamma Knife radiosurgery (GKRS), dealing almost exclusively with quantitative outcomes such as tumor control rate, AVM obliteration rate, and control rate of pain in trigeminal neuralgia. Qualitative research using surveys or interviews with patients, can explore issues not addressable by standard outcome measures, yet this methodology has been largely ignored within medical disciplines.

**Methods:** A qualitative case study with GK patients was undertaken. The design involves face-to-face semi-structured

interviews with 30 patients undergoing GKRS for a variety of indications. Patients are interviewed three times – when they sign the consent form for treatment, the day of treatment, and one to three months post-treatment. An interview guide is followed for each interview but patients are encouraged to expand on any issue they wish to pursue. The interviews are transcribed and subjected to modified thematic analysis. The study was passed by the Research Ethics Board at the University Health Network.

**Results:** Based on the first 15 interviews as of November 7, 2007, preliminary analysis reveals a number of themes. Two examples include: 1) patient satisfaction is generally high; and 2) patients feel that knowledge about GKRS may be suboptimal in the general medical community.

**Conclusions:** Qualitative research is a useful but underused methodology in most clinical medical disciplines, especially the surgical ones. It is relatively inexpensive and resource friendly, is accessible to essentially every clinician, and allows for exploration of issues not addressable by quantitative methods. It provides insights into patient care that can result in action designed to improve the patients' experience. GKRS is known to be a safe and effective treatment for many intracranial conditions. This study confirms that patient satisfaction is high and also highlights areas for improvement.

#### *Poster Exhibit*

#### **FRACTIONATED STEREOTACTIC TREATMENT OF BRAIN METASTASES USING TOMOTHERAPY AND IMAGE GUIDED MVCT: FOLLOW-UP ON THREE PATIENTS WHO COULD NOT BE TREATED WITH RADIOSURGERY**

*P. Sanghera, A.W. Lightstone*

Odette Cancer Centre, Toronto, Ontario, Canada

Three patients with recurrent brain metastases deemed appropriate for salvage radiosurgery could not be treated using the conventional linear accelerator protocol at our facility. One patient vomited during the first attempt at radiosurgery and refused further similar attempts. Two patients had received prior successful radiosurgery for brain metastases with the CRW (bolted pin-type) head-frame; later, when brain metastases were observed at new sites, they refused CRW treatment on the basis of previous discomfort.

As an alternative the patients were immobilized with masks and treated on Tomotherapy (2700Gy/5 to the PTV [GTV+3 mm]) while using MVCT guidance for manual sagittal rotation adjustments as necessary. All patients tolerated treatment well with no significant adverse effects. The first patient died after 12 months due to extracranial disease, without significant progression of the intracranial disease. At last follow-up (6 months) the other two patients were alive: one patient showed no intracranial progression; neurological imaging of the last patient had not been completed though there was no evidence of clinical progression. Their history and 12-month status will be presented.

The outcomes suggest that fractionated image guided stereotactic radiation therapy performed on a Tomotherapy device is feasible, well tolerated and can be very effective in controlling isolated brain metastases.

#### *Poster Exhibit*

#### **COMPARISON OF TG-21 AND TG-51 CALIBRATIONS OF A GAMMA KNIFE UNIT**

*M. van Prooijen, H.B. Michaels, Y-B. Cho and D. M. Galbraith*

Department of Radiation Physics, Princess Margaret Hospital, Toronto, Canada

At our hospital, it is standard practice to subject all linear accelerators to annual physics quality assurance (QA) which includes a check of the output dose rate calibration according to TG-51 methods. This practice was also adopted for our Gamma Knife 4C unit. At commissioning, the unit was calibrated using a method based on the ratio Ngas/Nx and the AAPM TG-21 protocol. To check the accuracy of our method, we recalculated the calibration using the exposure calibration method also described in TG-21. This method agreed with our first one to within 0 – 2.5 %, depending on the values determined for various constants in the equations. To convert to TG-51 requires a dose to water calibration (ND,w). Due to the spherical shape of the calibration phantom, polystyrene is used in place of water and an ND,w calibration factor should be obtained with a polystyrene buildup cap on the chamber in the NRC water phantom so that no further corrections are required. Results of this calibration are pending and expected in another month. A comparison of the 3 methods (2 from TG-21, 1 from TG-51) is shown and differences explained.

#### *Poster Exhibit*

#### **GAMMA KNIFE SURGERY FOR VESTIBULAR SCHWANNOMAS: THE FIRST TWO YEARS EXPERIENCE AT THE WINNIPEG CENTRE FOR GAMMA KNIFE SURGERY (24 - 48 MONTH FOLLOW-UP)**

*C. Kazina, M. West, A. Kaufmann*

University of Manitoba, MB

The Winnipeg Centre for Gamma Knife Surgery commenced operations November 3, 2003. As the management objective for Vestibular Schwannomas (VS) has shifted from complete tumor excision, to tumor growth control and functional preservation (namely serviceable hearing), large-series long-term outcome data from experienced GKS centers are confirming that GKS is an effective primary or adjuvant treatment for VS. The purpose of this study was to examine the first two years of The Winnipeg Centre for Gamma Knife Surgery in treating VS, which includes a patient population that now has two to four years of follow-up.

This study retrospectively examines all previously untreated unilateral VS cases that were treated at The Winnipeg Centre for Gamma Knife Surgery in its first two years of operations (n = 51). In all cases, a marginal tumor dose of 12 - 13 Gy was prescribed to the 50% isodose line. Patients with additional intracranial pathology or NF2 were excluded from this study. At the time of referral and at 24 - 48 month follow-ups, patient characteristics, patient signs and symptoms, and tumor size and nature on imaging were analyzed. Referral patterns to the centre were also examined. The early follow-up data suggest very good tumor growth control rates to date, with minimal short-term side effects and functional preservation.

**Poster Exhibit****POSTERIOR FOSSA (ARTERIOVENOUS MALFORMATIONS (PFAVMS): ANGIOARCHITECTURAL FEATURES AFFECTING OUTCOME**

*L. da Costa, C. Wallace<sup>1</sup>, M. Tymianski<sup>1</sup>, R. Willinsky, K. terBrugge, M. Schwartz<sup>2</sup>*

Division of Neurosurgery, Toronto Western Hospital, Toronto, Ontario<sup>1</sup>, Division of Neurosurgery, Sunnybrook Health Sciences Centre, Toronto, Ontario<sup>2</sup>

**Objective:** To study the effect on outcome of multimodality treatment of PFAVMs of angioarchitectural and clinical factors.

**Methods:** A review of the prospective data base of the University of Toronto Brain Vascular Malformation Study Group identified 64 patients with angiographically proven PFAVMs and complete follow-up, and correlated angioarchitectural features and mode of presentation with outcome as measured by the modified Rankin Score (mRS). Angioarchitectural features included associated aneurysms (AAs) and venous stenosis or ectasia. Presentation was dichotomized as hemorrhagic or non-hemorrhagic, and management was divided into observation, 1 modality and multiple modalities. The mRS was calculated at presentation and follow-up. An mRS of 4-6 was considered a poor outcome. The Fisher test evaluated the impact of angioarchitecture on presentation and initial and final mRS. Multiple logistic regression analysis was used to identify predictors of poor outcome, including treatment.

**Results:** Untreated patients had a lower mRS than treated patients at presentation and follow-up. Angioarchitecture did not predict mRS at presentation, but AAs were associated with a lower follow-up mRS ( $p=0.0078$ ). Presentation with hemorrhage was too frequent and venous stenosis too rare in this series for these factors to be significantly predictive. Multiple logistic regression analysis found AAs to be a strong predictor of poor outcome ( $p=0.0276$ ). There was a tendency to offer treatment to patients with AAs, but angioarchitectural features did not significantly influence the probability of being treated. The outcome of treated patients was not significantly different from untreated patients.

**Conclusion:** AAs increase the probability of hemorrhage and are a predictor of worse outcome despite multimodality management. Perhaps a more conservative approach is indicated for some unruptured PFAVMs or when a cure is not anticipated.

**Poster Exhibit****STEREOTACTIC BODY RADIOTHERAPY (SBRT) FOR BENIGN SPINAL TUMORS: PRELIMINARY EXPERIENCE AT THE UNIVERSITY OF CALIFORNIA, SAN FRANCISCO**

*A. Sahgal<sup>1</sup>, D. Chow<sup>3</sup>, C. Ames<sup>3</sup>, L. Ma<sup>2</sup>, K. Lamborn<sup>4</sup>, C. Chuang<sup>2</sup>, K. Huang<sup>2</sup>, A. Aiken<sup>5</sup>, P. Petti<sup>2</sup>, P. Weinstein<sup>3</sup>, D. Larson<sup>2</sup>*

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**Objective:** SBRT may be a treatment option for some patients with benign spinal tumors. We evaluate our preliminary experience using the Cyberknife.

**Methods:** Since 2003, we identified 16 consecutively treated patients comprising 19 benign spinal tumors. Histologic types included neurofibroma (11), chordoma (4), hemangioma (2), and meningioma (2). Three patients had Neurofibromatosis Type 1 (NF1). One tumor (chordoma) had been previously irradiated, and not considered in the local failure analysis. Local failure was based clinically on symptom progression and/or based on imaging. All patients had follow-up imaging.

**Results:** Median follow-up is 25 months (2-37), and one patient (with NF1) died at 12 months from a stroke. Indications for SBRT consisted of either adjuvant to subtotal resection (5/19), primary treatment alone (12/19), or as a boost following external beam radiotherapy (1/19). The median total dose/number of fractions/prescription isodose to the gross tumor volume was 21 Gy (10-30)/3 (1-5)/80% (42-87). The median tumor volume was 7.6 cc (0.2-274.1). The median V100 (volume V receiving 100% of the prescribed dose) and maximum tumor dose was 95% (77-100) and 26.7 Gy (15.4-59.7), respectively. Three tumors progressed at 2, 4, and 36 months post-SBRT ( $n=18$ ). Two tumors were neurofibromas (in both NF1 patients), and the third, a solid intramedullary hemangioblastoma. The 12-month freedom from progression is 89% (C.I.= 63%-97%). Based on radiologic follow-up, 2 tumors had MRI documented progression, 3 had regressed, and 13 were unchanged ( $n=18$ ). No acute grade 3-5 toxicity was observed. A spontaneous tumor cyst 2 months post-SBRT may represent sub-acute radiation toxicity. No late toxicity has been observed.

**Conclusion:** With short follow-up, local control and morbidity following spine SBRT for benign spinal tumors appear acceptable. Greater doses for neurofibromas in patients with NF1 may be required to improve local control. Further follow-up is required to determine long-term outcomes.

**Poster Exhibit****3T MRI FOR GAMMA KNIFE® RADIOSURGERY TREATMENT PLANNING: CLINICAL RELEVANCE**

*D. MacFadden, B. Zhang<sup>1</sup>, K. Brock, M. Hodaie<sup>2</sup>, N. Laperriere<sup>3</sup>, M. Schwartz<sup>4</sup>, M. Tsao, M. Cusimano<sup>5</sup>, J. Stainsby, H. Sharpe, D. Jaffray, M. Bernstein<sup>2</sup>, D. Mikulis, C. Ménard<sup>3</sup>*

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**Objectives:** The standard imaging modality used for Gamma Knife® (GK) Radiosurgery (RS) treatment planning is 1.5 Tesla Magnetic Resonance Imaging (MRI). Improved image quality with 3T MRI may improve targeting/delineation reproducibility. The objectives of this study were to investigate the use of 3 Tesla MRI for GK RS planning in two clinical applications: 1) delineating tumor volumes (TV) and 2) functional isocenter targeting.

**Methods:** TV Delineation: Two radiation oncologists and two neurosurgeons delineated TVs for patients ( $n=4$ ) with intracranial

tumors (3 vestibular schwannoma, 1 meningioma), using CT and MR imaging at 1.5T and 3T. Registration of MRI to CT was based on rigid stereotactic fiducials. TV spatial congruency was determined by the mean distance between representative surfaces at 1.5T and 3T. TV reproducibility was assessed by vector distances between surfaces and by volume congruency. Isocenter Targeting:

Two Radiation Oncologists and one Neurosurgeon each generated Trigeminal Neuralgia (TN) treatment plans for the patients (n=5) based on MRI at 1.5T and 3T. Spatial congruency and reproducibility of targeting at 1.5T and 3T were determined by comparing mean and variance of isocenter coordinates.

*Results:* 3T images qualitatively appeared to give better resolution of anatomic structures at higher magnification. TV Delineation: Mean distance between representative TV surfaces at 1.5T vs. 3T was 0.7(SD=0.3)mm. No differences ( $p>0.93$ ) were found in TV volume congruence (92(SD=6)%[1.5T] vs. 92(SD=6)%[3T]) or inter-observer TV mean distances (0.7(SD=0.4)mm[1.5T] vs. 0.7(SD=0.3)mm[3T]). Isocenter Targeting: No statistically significant difference ( $p>0.23$ ) was found between mean or standard deviations of isocenter coordinate locations at 1.5T and 3T.

*Conclusions:* Despite subjectively superior image quality, 3T MRI proved comparable but not clearly superior to 1.5T MRI, in GK RS TV delineation and isocenter targeting, under the imaging conditions investigated.

#### ACKNOWLEDGEMENTS

Many thanks to my colleagues and staff who helped organize the meeting: most importantly Giulia Dagostino, and also Luis Souhami, Horacio Patrocinio, Russell Ruo, Mary Vescio and Terry Fossetti. Thanks to François Deblois for putting together a wonderful website and to Dr Hodaie who organized the functional radiosurgery symposium. Finally, thanks to the other members of the abstract review committee for their rapid and pertinent comments: Dr Jean-Paul Bahary, Dr Michael Schwartz and Dr Brenda Clark.

#### DISCLOSURE

Unrestricted educational grant support for this meeting was received from: Accuray Inc., American Shared Hospital Services, BrainLAB Inc., Elekta Canada inc., Integra Radionics, Tomotherapy Inc. and Varian Medical Systems.