Otolaryngologist’s Perspective of Stereotactic Radiosurgery

Douglas E. Mattox, M.D.
25th Alexandria International Combined ORL Conference
April 18-20, 2007

Acoustic Neuroma

Benign tumor of the schwann cells of the vestibular nerve
Develops at junction of the glia and schwann cells
Third most common intracranial tumor
Unilateral hearing loss the most common presenting symptom
Presenting Symptoms

Unilateral hearing loss – 95%
Tinnitus – 65%
Dizziness – 45%
Trigeminal hypoesthesia – 5%
Headache – 2%

Diagnosis: MRI with Gadolinium
Acoustic Neuroma Treatment Options

Observation
Microsurgical removal
Stereotactic radiosurgery

Natural History of Acoustic Neuroma

Brackmann et al, 1999
N = 119
Age 37 – 84, mean 65 years
Mean follow-up 2.5 years
DEFINED GROWTH AS > 2 mm change
66% did not grow or grew < 2 mm.
30% grew > 2 mm.
4% regressed
Growth Rate

Shin et al, AJO, 2000
N = 97
Mean follow up interval 15 months
Stable – 36%
Regressed – 11%
Grew – 56%
Mean annual growth 1.5 mm/yr

Growth Rate

Brackmann et al, 1999
N = 119
Mean growth rate for all tumors (119) – 1.2 mm/yr
30% Tumors that grew > 2 mm.
Mean growth rate 3.8 mm/yr
Incidence of growth would be greater with longer follow-up.
Rapid Growing Tumors

Brackmann et al, 1999
N =119
36 (30%) grew during study period
   Growth > 5 mm/yr – 6 patients
   Growth > 10mm/yr – 3 patients
   Growth > 25mm/yr – 1 patient

Predictors of Growth

Brackmann et al, 1999
Not significant
   Age
   Gender
   Side of tumor

Significant
   Tumor > 20 mm
Acoustic Neuroma Treatment Options

Observation
Microsurgical removal
Stereotactic radiosurgery

Acoustic Neuroma: Observation

Shin et al, AJO 2000
N = 97 patients
Mean interval of observation 15 months
6 Surgery, 6 SRS
60 Still under observation
25 Lost to follow up
Acoustic Neuroma: Observation

Marseilles Hospital experience (Regis et al)
54 patients with small acoustic neuroma and useful hearing observed with serial imaging
72% of patients had tumor enlargement and underwent SRS
Useful hearing preserved in 20%

Acoustic Neuroma: Observation

Multi-institutional Japanese series (Shirato et al)
27 patients, mean f/u average 3 years
Mean tumor diameter 16 mm
11/27 (43%) required treatment
   7 surgery
   4 SRS
Results of Observation

- 64 yr old male
- Decreased hearing
- Observation recommended

2 ½ years later

Observation

- Must be used cautiously
- Small tumors
- Elderly patient
- Serial scans initially every 6 months
- Anticipate additional therapy will be required in the majority of patients
Surgical Approach for Acoustic Neuroma

Translabyrinthine
Retrosigmoid
Middle fossa

Translabyrinthine

Advantages
- Shortest and most direct route
- No cerebellar retraction
- Facial nerve identified at the outset of the dissection
- Potential CSF leak prevented by obliteration of cavity and Eustachian tube

Disadvantages
- Automatic loss of hearing
- Limited exposure for very large tumors
Retrosigmoid

Advantages
- Potential preservation of hearing
- Medial exposure for tumors adherent to the brainstem.

Disadvantages
- Limited exposure of lateral internal auditory canal

Middle fossa

Advantages
- Potential preservation of hearing

Disadvantages
- Challenging dissection
- Applicable to small tumors only
Results of Surgical Removal

Facial function preserved in most cases

Hearing preservation in small tumors

Recurrence rare

Why would a perfectly normal surgeon
Why would a perfectly normal surgeon go to the Dark Side?

What is Stereotactic Radiosurgery?
What is Stereotactic Radiosurgery?
Why is it “Surgery”?

No attempt at tissue sparing within the treatment volume.

Use of focused radiation beam to cause focal damage

Radiation from multiple sources or beams focused on a single limited target

Radiation dose is much higher than XRT
What is Stereotactic Radiosurgery? Why is it ‘Surgery’?

High precision with CT or MRI based localization system

Treatment given in single (or a few) treatments

None of the usual side effects of XRT (hair loss, mucositis, skin damage)

History of Stereotactic Radiosurgery (SRS)

Dr. Lars Leksell
Gamma Knife with discoid collimators (1967)
Gamma Knife with circular collimators (1975)
Linear accelerator
Linear accelerator with dynamic arc conformation.
Applications of SRS

Benign Disease – 58%
- Tumors – 31%
  - Meningioma – 45%
  - Acoustic Neuroma – 29%
  - Pituitary Adenoma – 14%
- Vascular Lesions – 15%
  - AVM – 96%

Benign Diseases (cont’d)
- Functional Disorders
  - Trigeminal Neuralgia – 87%
- Malignant Tumors – 42%
  - Metastases – 67%
  - Gliomas – 27%

SRS for Benign Disease

- Acoustic neuroma
- Glomus tumors
- Trigeminal neuralgia
- AVMs
- Meningioma
- Pituitary adenoma
Results of SRS

Definition of Successful Treatment

No increase in size of tumor

No new neurological Symptoms
U of Pittsburgh SRS Experience with Acoustic Neuromas

402 patients treated over 10 years, 24% having had prior surgery
Local control at 10 years was 95% (62% smaller, 33% stable)
Facial numbness and weakness 8% overall in series; in recent patients treated with <14 Gy peripheral dose the risk was 0%
In modern cohort, useful hearing was preserved in 68% with improvement in 7%
Tinnitus was improved in 2/3 of patients

Acoustic Neuroma Radiosurgery (LINAC)

University of Florida (Foote et al)
N = 149/10 years
14 Gy
Local control – 93%
V/VII complications – 12%/10%
5%/2% after 1994
Best results with 12.5 Gy
### Acoustic Neuromas—Surgery or Radiosurgery?

**University of Pittsburgh experience**
- 87 patients treated in 1990-1991 with tumors < 3 cm in diameter (40 with surgery; 47 with SRS)

<table>
<thead>
<tr>
<th></th>
<th>Surgery</th>
<th>SRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tumor Control</td>
<td>98%</td>
<td>94%</td>
</tr>
<tr>
<td>Preservation of Useful Hearing</td>
<td>14%</td>
<td>75%</td>
</tr>
<tr>
<td>Normal Facial Nerve Function</td>
<td>63%</td>
<td>83%</td>
</tr>
</tbody>
</table>

### Acoustic Neuroma: Surgery vs. SRS

**Marseilles Hospital experience (Regis et al)**
- 100 consecutive SRS patients
- 110 matched microsurgery patients

**Results**
- No difference in tinnitus, vertigo, imbalance.

<table>
<thead>
<tr>
<th></th>
<th>Surgery</th>
<th>SRS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tumor Control</td>
<td>91%</td>
<td>97%</td>
</tr>
<tr>
<td>Hearing Preservation</td>
<td>38%</td>
<td>70%</td>
</tr>
<tr>
<td>Facial Weakness</td>
<td>47%</td>
<td>0%</td>
</tr>
<tr>
<td>Facial Numbness</td>
<td>29%</td>
<td>4%</td>
</tr>
</tbody>
</table>
Implications for Salvage Surgery

Lee et al 2003
4 cases operated on after SRS
Variable fibrosis
Histology typical of vestibular schwannoma.
Preservation of VII in all cases

Second Tumors and Malignant Degeneration after Radiation

Low incidence of spontaneous malignant transformation of schwannomas
Hanabusa et al 2002
Spontaneous malignant degeneration

Shin et al 2002
Malignant transformation 6 yrs after SRS. Tumor developed new TP53 mutation in the recurrent tumor not present before SRS
Difference between Gamma Knife and Dynamic Conformational Arc Linear Accelerator

<table>
<thead>
<tr>
<th>LINEAR ACCELERATOR</th>
<th>GAMMA KNIFE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photon radiation</td>
<td>60Cobalt</td>
</tr>
<tr>
<td>No radiation when turned off</td>
<td>Continuous radiation source</td>
</tr>
<tr>
<td>Radiation given in series of arcs</td>
<td>Radiation given in multiple overlapping spheres</td>
</tr>
<tr>
<td>Radiation beam conform to tumor geometry</td>
<td>Multiple spheres conform to tumor geometry</td>
</tr>
<tr>
<td>Adapted to existing linear accelerator</td>
<td>High initial cost</td>
</tr>
</tbody>
</table>

Gamma Knife Radiosurgery
LINAC

Dynamic MLC Treatments

120 leaf MLC

(Dynamic MLC Treatment)
SRS Protocol at Emory

Diagnosis – must be sure treatment can be rendered without pathologic confirmation.

Thin section planning MRI

Day of treatment
  Application of head frame with conscious sedation
  CT with head frame
  Fusion of CT and MRI data, treatment planning
  Treatment with linear accelerator ~ 20 minutes
  Discharge

Application of Head Frame
Treatment

Treatment Monitoring
Fractionated Stereotactic Radiotherapy

Generally done when dealing with targets that are either too large (>3.5-4 cm) for radiosurgery or when a critical normal structure (Optic nerves/chiasm/brainstem) is too close to the tumor to allow safe treatment.

Fractionation patterns have varied from conventional daily dosing (1.8-2 Gy/day over 5-6 weeks) to hypofractionated treatments (4 Gy x 5-6 txs).

Not as spatially accurate as Stereotactic Radiosurgery because non-invasive fixation is employed.

Single Dose vs. Fractionated SRS

Single treatment

Hypofractionated (Fractionated SRS) 25 Gy/5fx to 30 Gy/10 fractions

Conventional Fractionation (SRT) 57 Gy/23 fractions
Masks for FSR immobilization

Fractionated Stereotactic Radiotherapy vs. SRS for Acoustic Neuromas (Netherlands Prospective Trial)

129 patients assigned to receive 20-25 Gy in 4-5 fractions (80 patients) or 10-12.5 Gy in one fraction (49 patients) depending on dental status. Imaging characteristics were the same. Edentulous patients were older.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>1 Fx</th>
<th>4-5 Fx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Control</td>
<td>100%</td>
<td>94%</td>
</tr>
<tr>
<td>VII nerve complications</td>
<td>7%</td>
<td>3%</td>
</tr>
<tr>
<td>V nerve complications</td>
<td>8%</td>
<td>2%</td>
</tr>
<tr>
<td>Hearing preservation</td>
<td>75%</td>
<td>61%</td>
</tr>
</tbody>
</table>
Acoustic Neuroma: Fractionated SRS

Probably no advantage of fractionated SRS or SRT over low dose single fraction (12 to 12.5 Gy) SRS for hearing preservation.

Decision for FRS is made on basis of size and brainstem invagination.

SRS for Acoustic Neuroma
Emory Experience

First initiated February, 1990 (Mattox 8/03)
81 Tumors treated SRS only
22 Tumors treated with FRS
Dose reduced to 12 Gy since 2001
No permanent facial paralysis
2 transient paralysis – resolved with steroids
No tumor progression
Radiosurgery – Glomus Tumors

126 patients from 5 institutions (Foote et al)
Dose 12 – 18 Gy

Results

100% local control
Symptomatic improvement in 60%
Imaging response: Decrease 39%, Stable 61%
Complications 0 – 3%

Radiosurgery – Glomus Jugulare Tumors

Emory Experience

1/1/2000 to 1/1/2005
12 Glomus jugulare tumors in 11 patients
11 Female, 1 Male
Median age 55 (37 – 83)
2 Failed previous surgical therapy with tumor growth
Radiosurgery – Glomus Jugulare Tumors
Emory Experience

Symptoms
- Pulsatile tinnitus – 73%
- Hearing loss – 64%

Median tumor size – 6.5 cm³ (2.4 – 23)

SRS
- 8 Patients
- Dose 13.4 Gy

FSR
- 4 Patients (brainstem invagination)
- Dose 50.4 Gy
Radiosurgery – Glomus Jugulare Tumors
Emory Experience

Median followup – 27 months (4 – 63)
No immediate, acute or chronic complications
8 of 11 patients reported partial or complete improvement of symptoms
No progressive symptoms, No lower cranial nerve deficits
4/12 tumor reduction, 8/12 stable

Surgery vs. Stereotactic Radiosurgery for Acoustic Neuroma

MICROSURGERY
Younger patient
Rapidly growing tumor
Tumor any size
Compression of brainstem
Pathologic confirmation
Recurrent tumor after SRS

RADIOSURGERY
Older, medically unstable patient
Tumor ≤ 3 cm.
Significantly reduced peritreatment complications
Thanks for Listening