

Gamma knife radiosurgery for Koos grade 4 vestibular schwannomas

David Mathieu MD FRCSC, Christian Iorio-Morin MD PhD, Fahd Al Subaie MD MSc FRCSC

Division of neurosurgery, Université de Sherbrooke, Centre Hospitalier Universitaire de Sherbrooke

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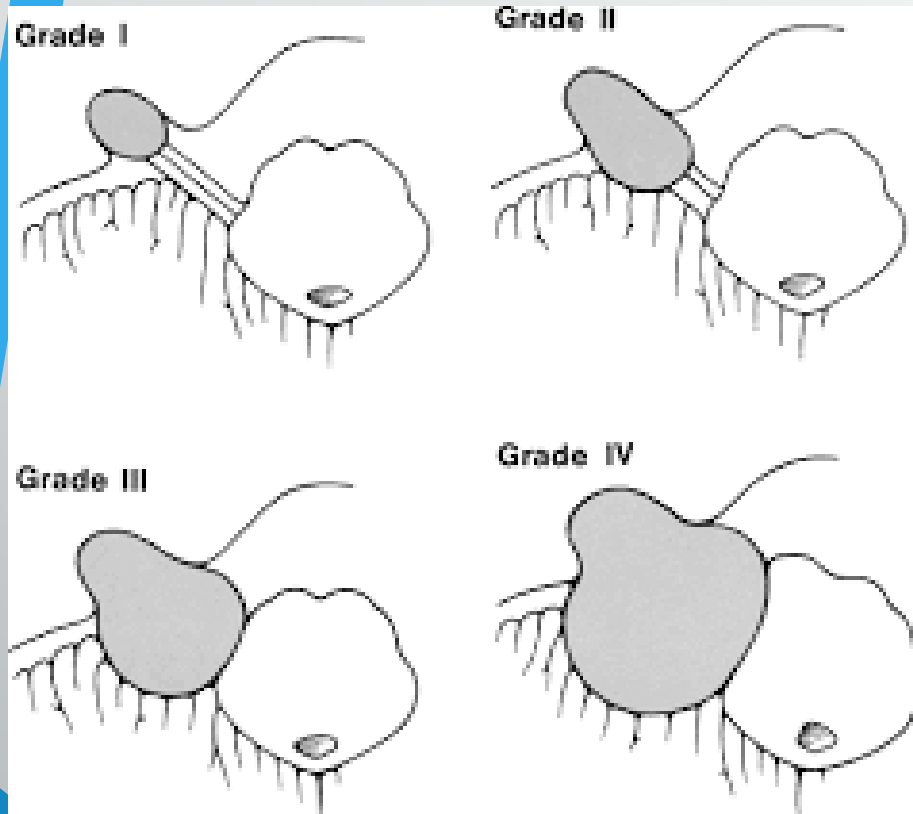
Disclosure

- No conflict of interest to disclose

Background

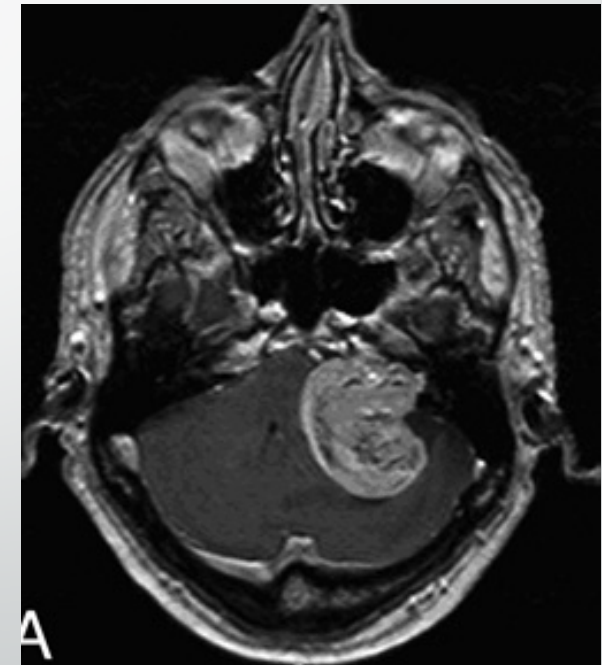
- Gamma knife radiosurgery (GKRS) is recognized as a first line management option for small to moderate-size vestibular schwannomas
 - Tumor control rates 90-98%
 - Low morbidity
- Management of larger size tumors remains a subject of debate
 - Koos classification used to orient management

Koos classification



Koos et al, JNS, 1998

Koos grade 4 tumors



Objectives of the study

- Evaluate the efficacy and safety of GKRS for appropriately selected Koos grade 4 VS
 - Tumor control
 - Hearing evolution
 - Facial preservation
 - Radiation-induced complications

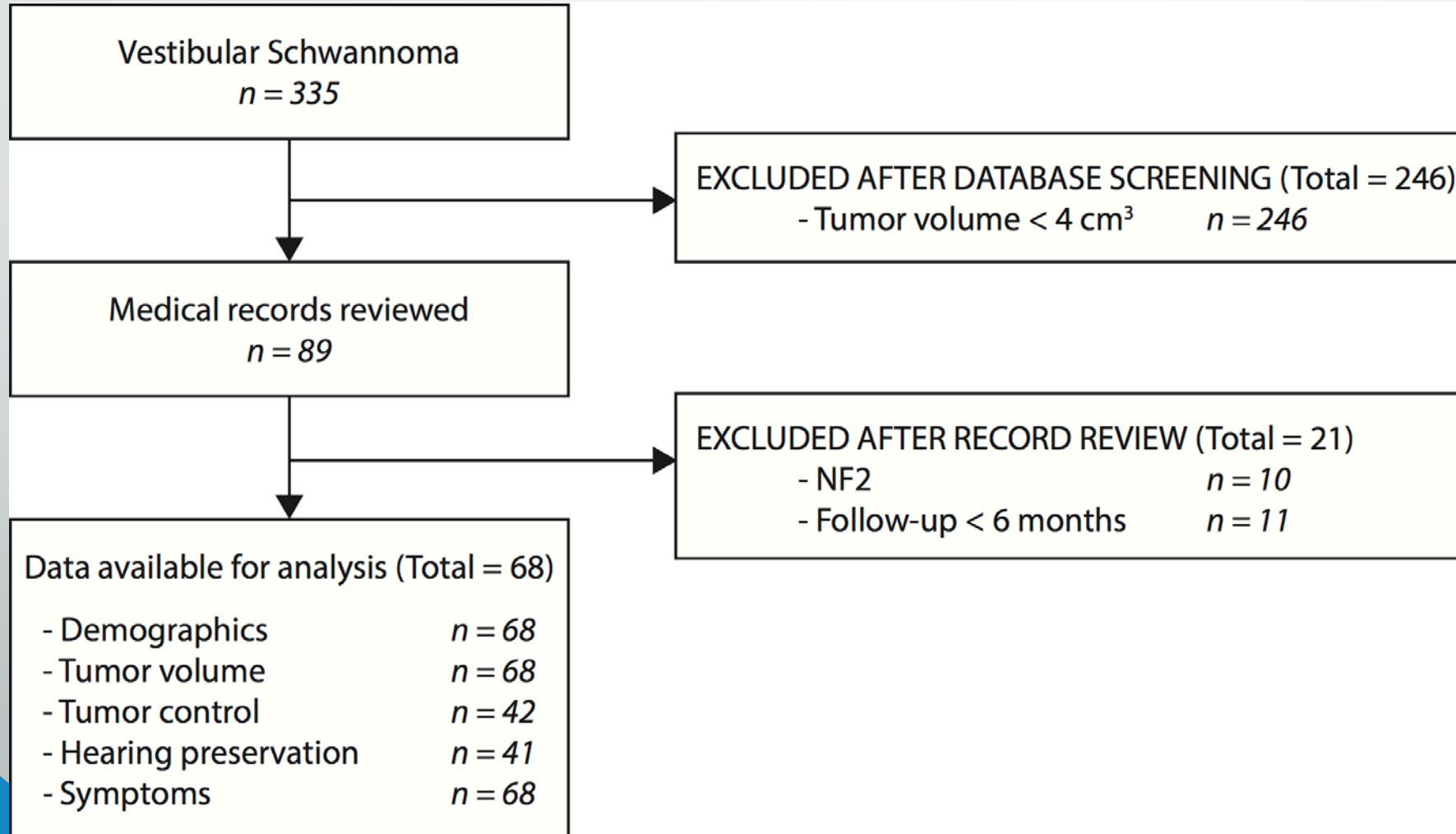
Inclusion criteria

- Patients treated in Sherbrooke between August 2004 and April 2014
- Koos grade 4 tumors with volume more than 4 cc
- Minimum follow-up 6 months
- No NF2
- No symptomatic intracranial hypertension or brainstem compression

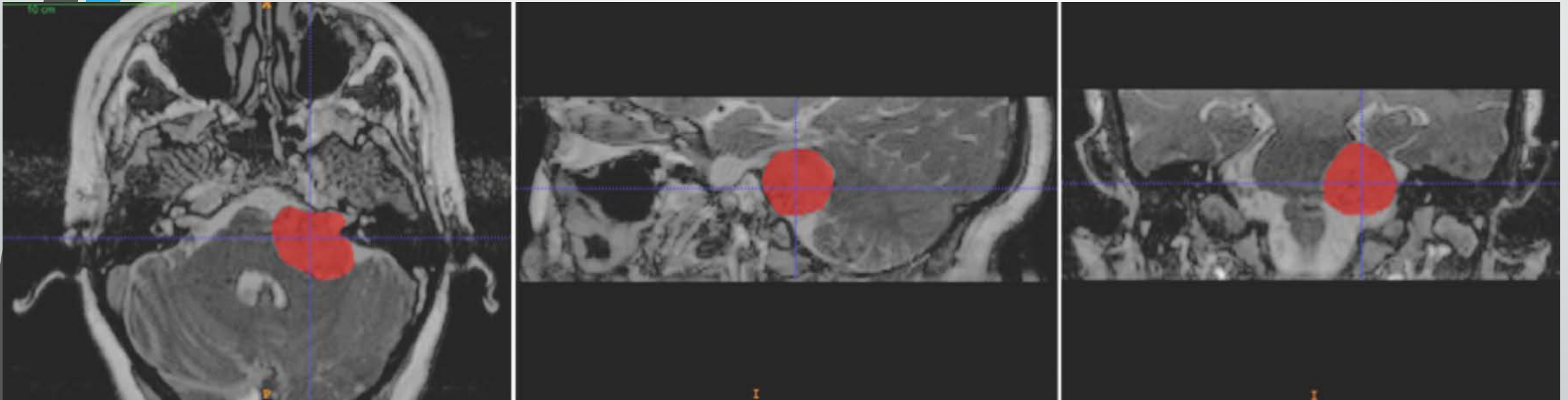
Treatment protocol

- MR sequences: contrast-enhanced MPRAGE and CISS-3D
- Tumor: usual margin dose of 12 Gy to treatment isodose
- Brainstem: limit 12-Gy volume to < 1 cc
- Cochlea: aim for mean dose < 4 Gy
- Semi-circular canals: no dose constraint
- Trigeminal nerve: no dose constraint

Patient workflow



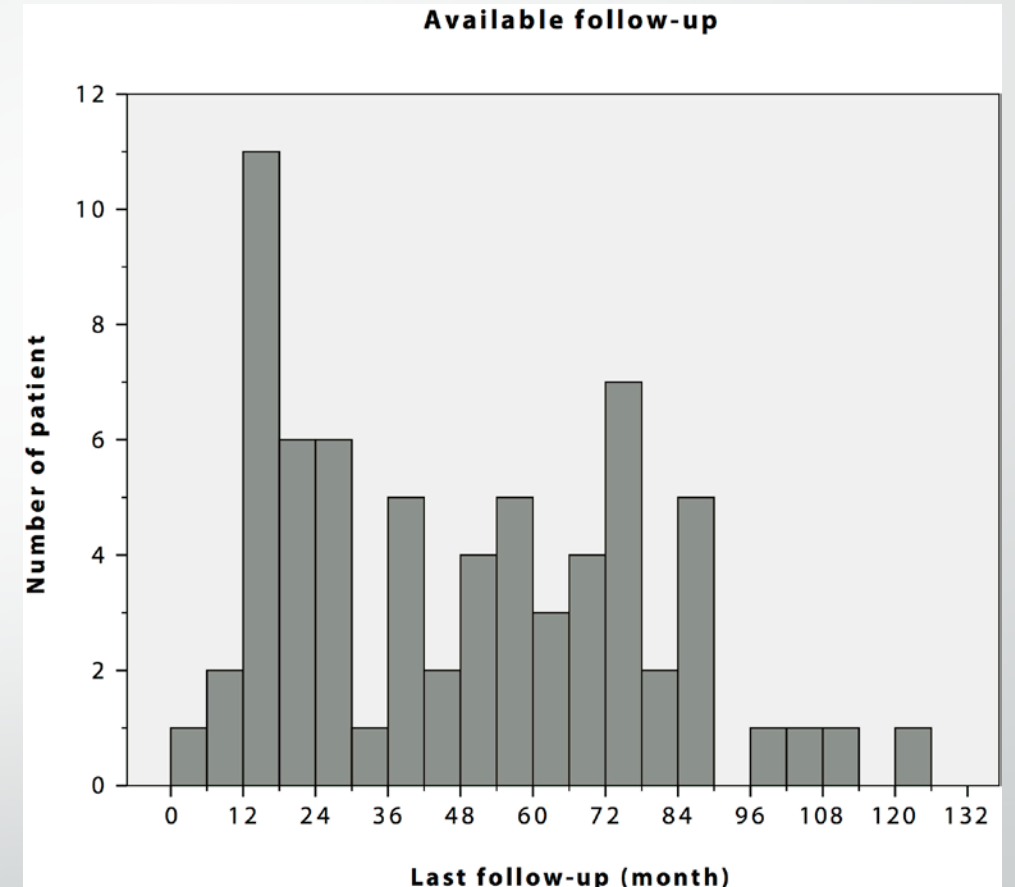
Volumetric analysis



Performed using *itk-SNAP software version 3.2.0* on a dedicated station

Patient population

Median age at radiosurgery (range)		58 (16-85)
Male:Female ratio		1.4:1
Preceding surgical intervention		
	Resection	13 (19%)
	VP shunt insertion	5 (7%)
Baseline hearing and facial function		
Gardner-Robertson grade (hearing function)		
	I	16 (24%)
	II	24 (35%)
	III	15 (22%)
	IV	2 (3%)
	V	11 (16%)
House-Brackmann scale (facial function)		
	I	62 (91%)
	II	0 (0%)
	III	1 (1.5%)
	IV	0 (0%)
	V	1 (1.5%)
	VI	4 (6%)



Median follow-up 47 months (6-125)

Tumor characteristics

Indication for GKRS

Primary treatment	55 (81%)
Adjuvant treatment for residual tumor following surgery	8 (12%)
Recurrence following gross total resection	5 (7%)

Radiological tumor characteristics at time of GKRS

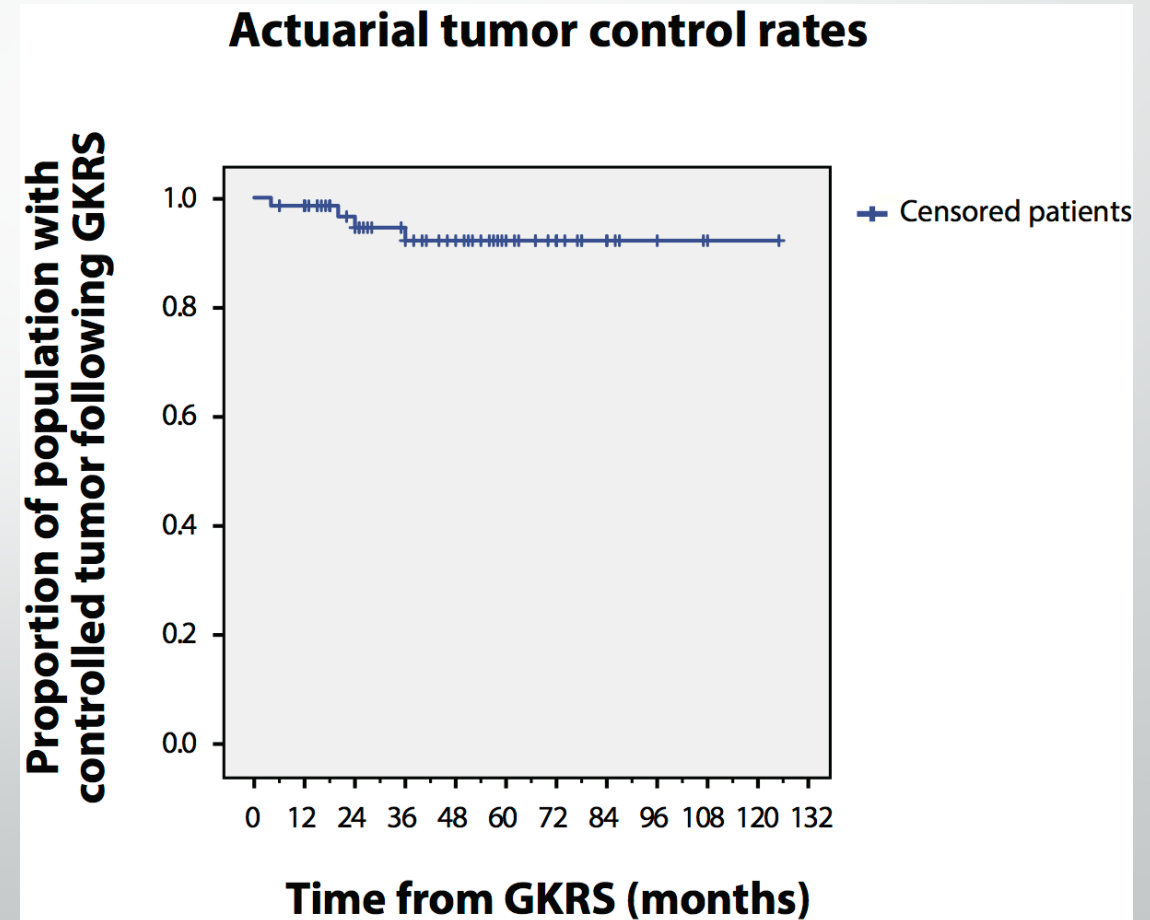
Median volume in cc (range)	7.4 (4-19)
Median max CPA diameter in cm (range)	2.7 (2-4)
Cystic component	13 (19%)
Median cyst size in cm ³ (range)	2 (1-4.2)

Dosimetry

Median marginal dose (range)	12 Gy (11-13)
Median isodose line used (range)	50% (50-55)
Median cochlear radiation dose (range)	Gardner-Robertson grade I & II Mean dose: 4.3 Gy (2.4-8.3) Maximal dose: 6.8 Gy (3.7-13.1) Gardner-Robertson grade III, IV & V Mean dose: 5.1 Gy (3.5-6.7) Maximal dose: 7.6 Gy (5.3-15.4)
Median semi-circular canals dose (range)	Mean dose: 3.7 Gy (2.7-7) Maximal dose: 7.5 Gy (2.9-11.6)
Median brainstem radiation dose (range)	Mean dose: 3.3 Gy (2.1-4.5) Maximal dose: 11.9 Gy (10-14.9)
Median trigeminal nerve radiation dose (range)	Mean dose: 7.2 Gy (5.9-8.1) Maximal dose: 11.7 Gy (10.8-13.2)

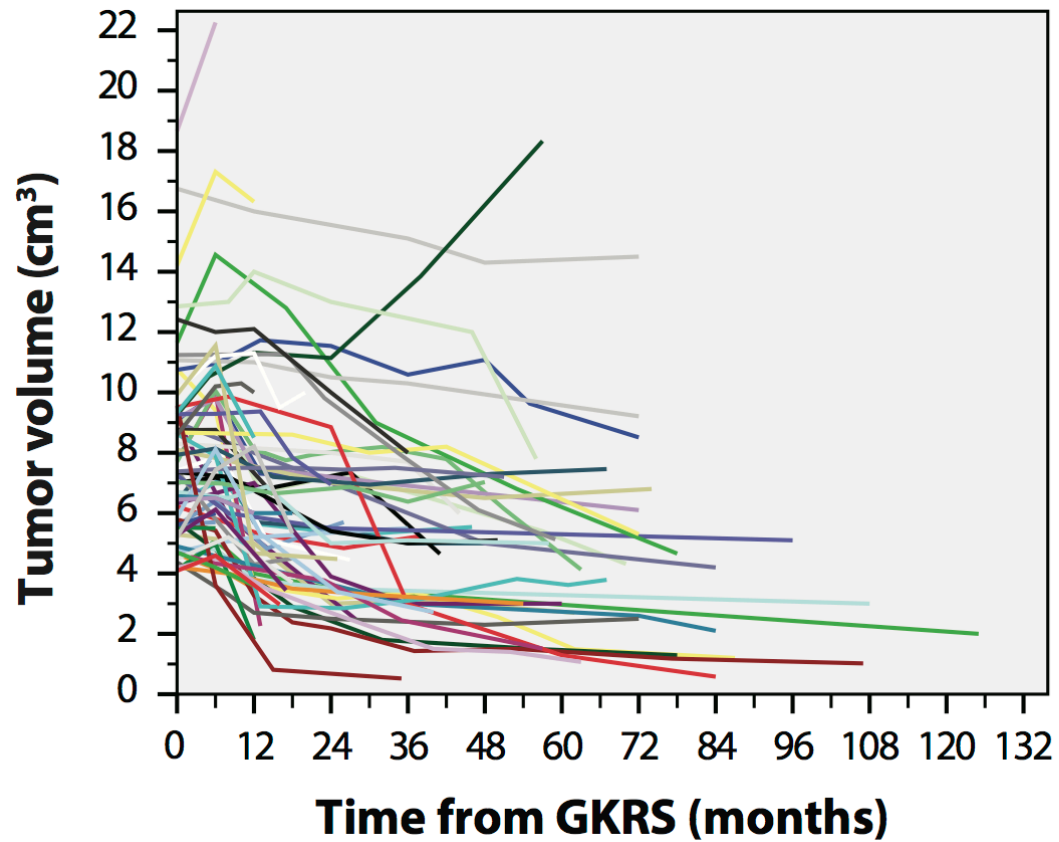
Tumor control

- Crude local control 94% (4 failures)
- Actuarial control:
 - 2 years: 95%
 - 10 years: 92%
- Transient volume increase in 41%
 - At median of 8 months (6-13 mo)
- Increased risk of failure (univariate only)
 - higher tumor volume
 - Lower dose

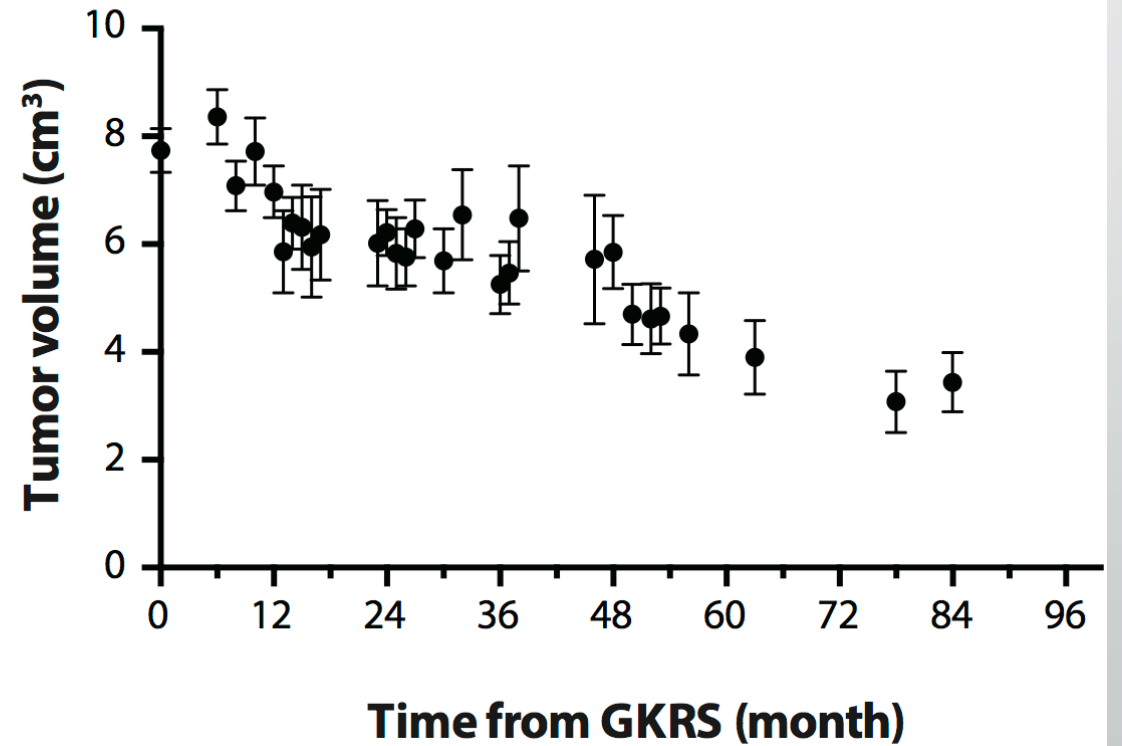


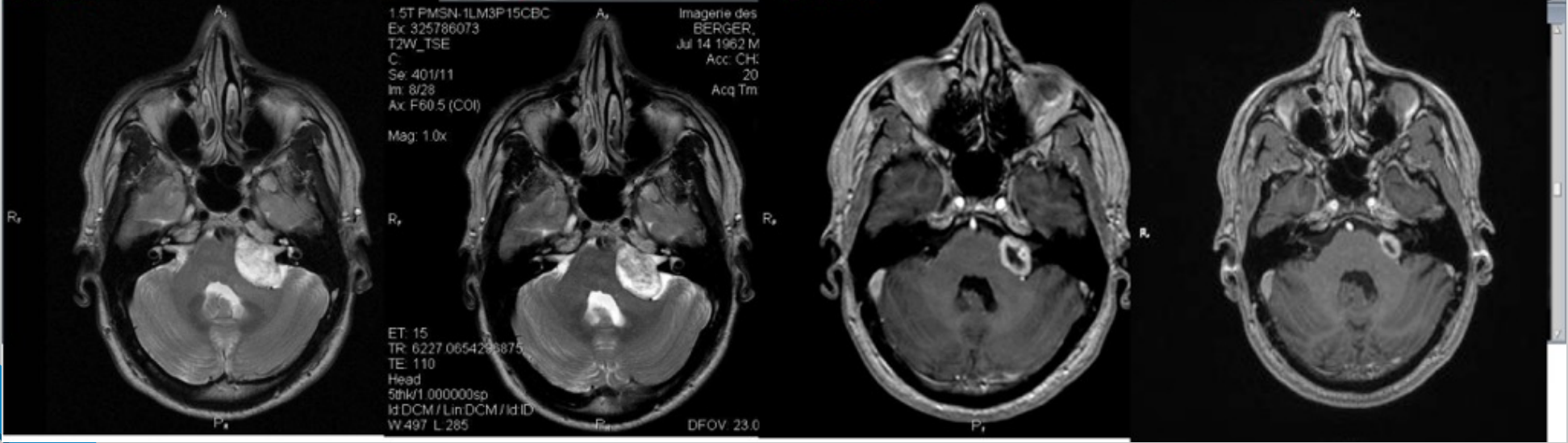
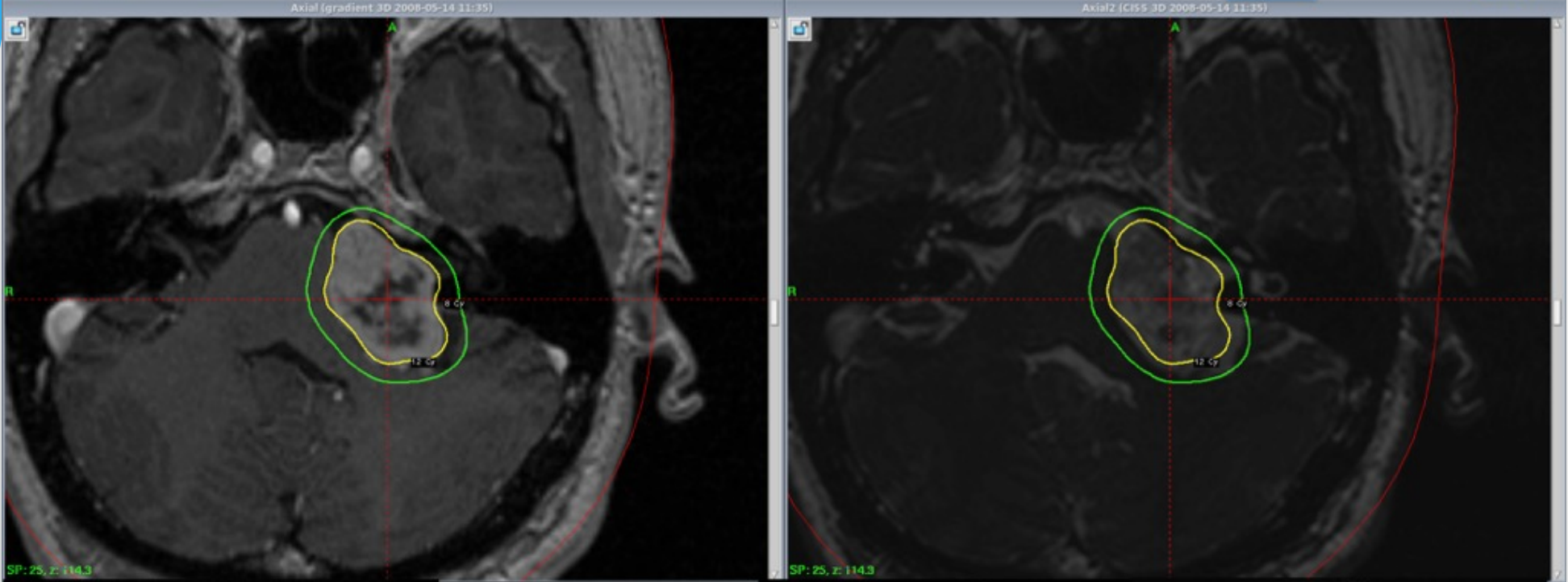
A

Tumor volume evolution for individual patients

**B**

Modeled tumor volume evolution following GKRS





1 year

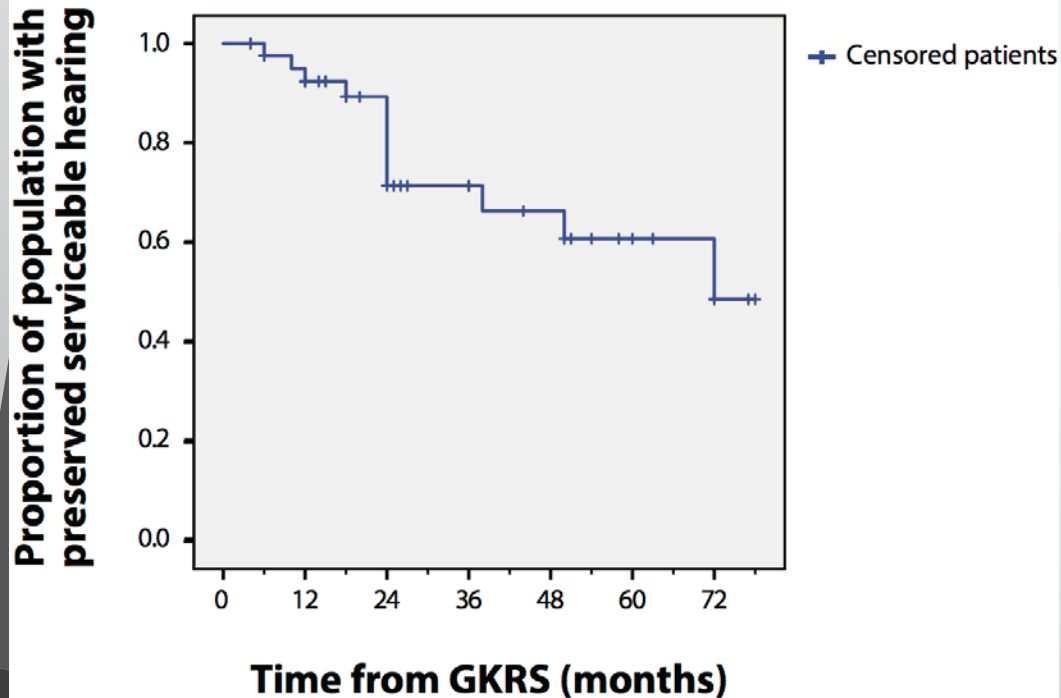
2 years

3 years

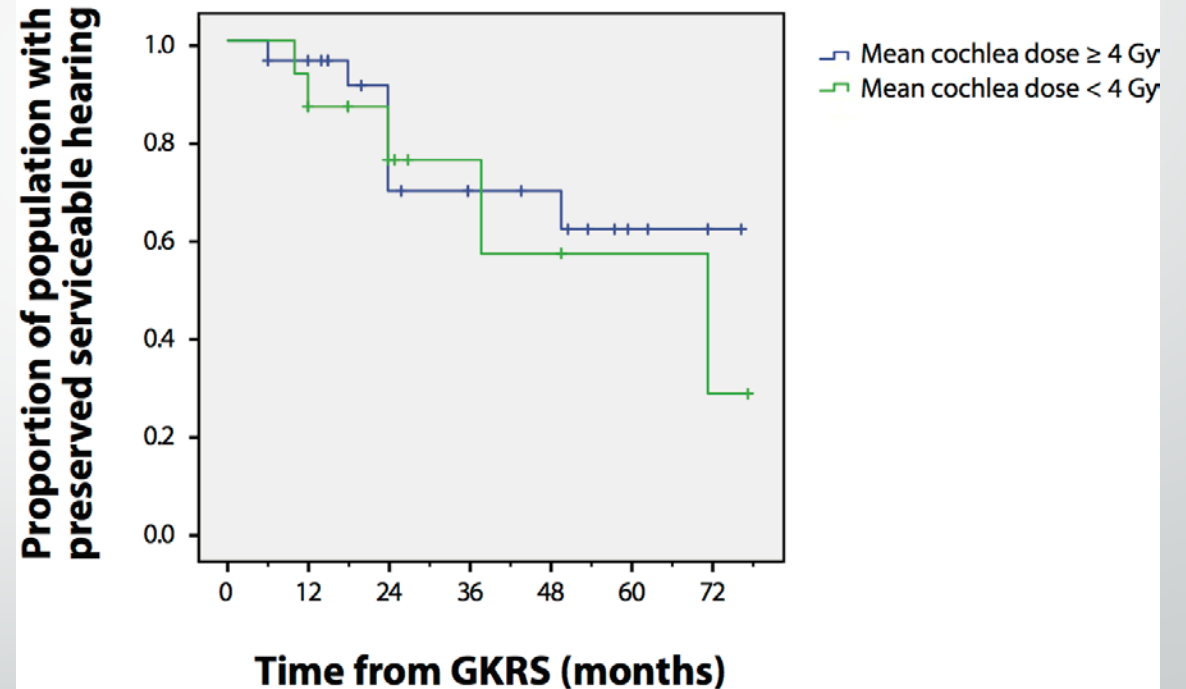
5 years

Hearing preservation

Serviceable hearing preservation



Serviceable hearing preservation stratified by cochlea dose

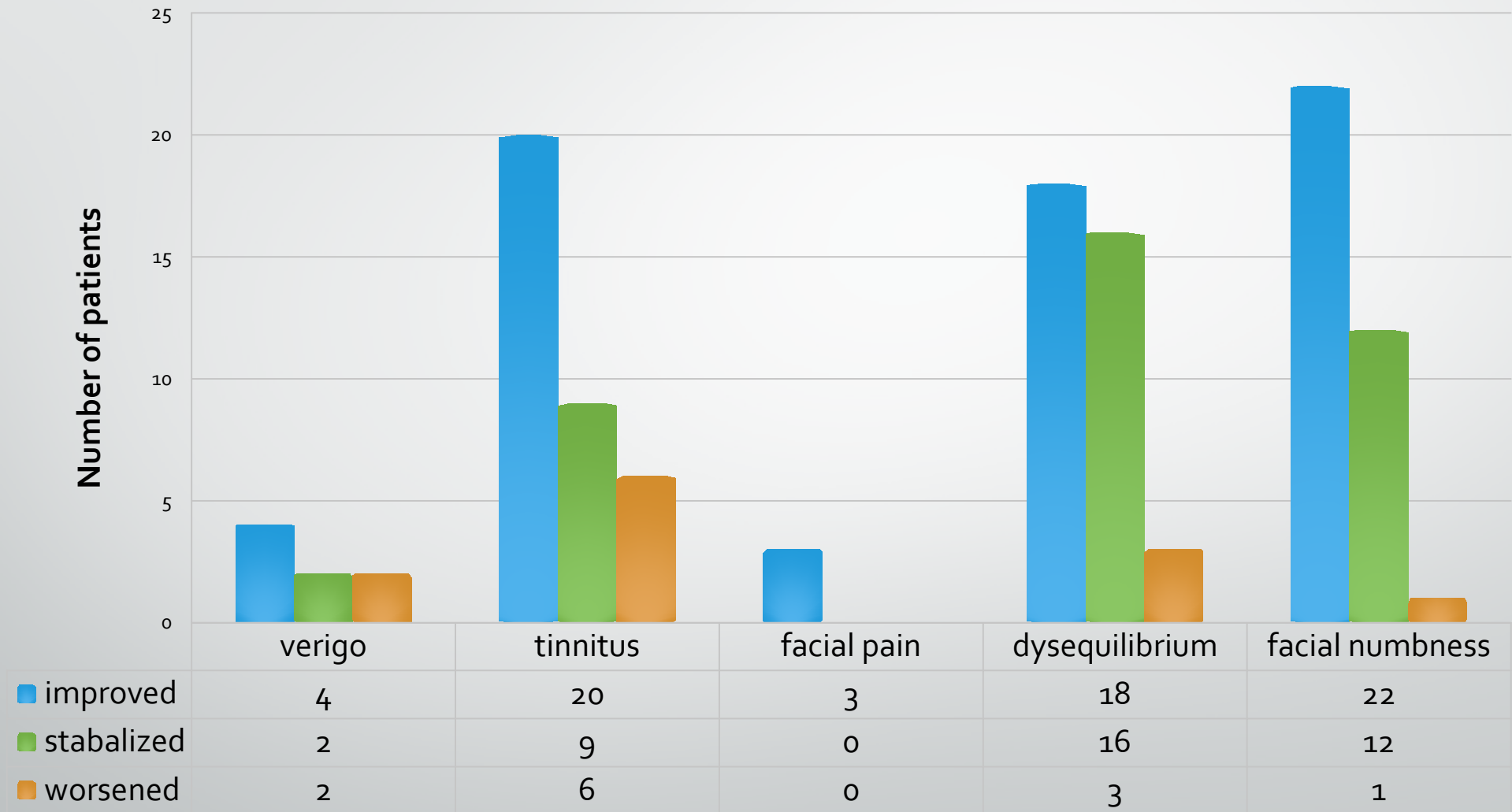


Actuarial hearing preservation:

85% at 2 years, 49% at 5 years

No significant factor for hearing preservation

Evolution of initial symptoms

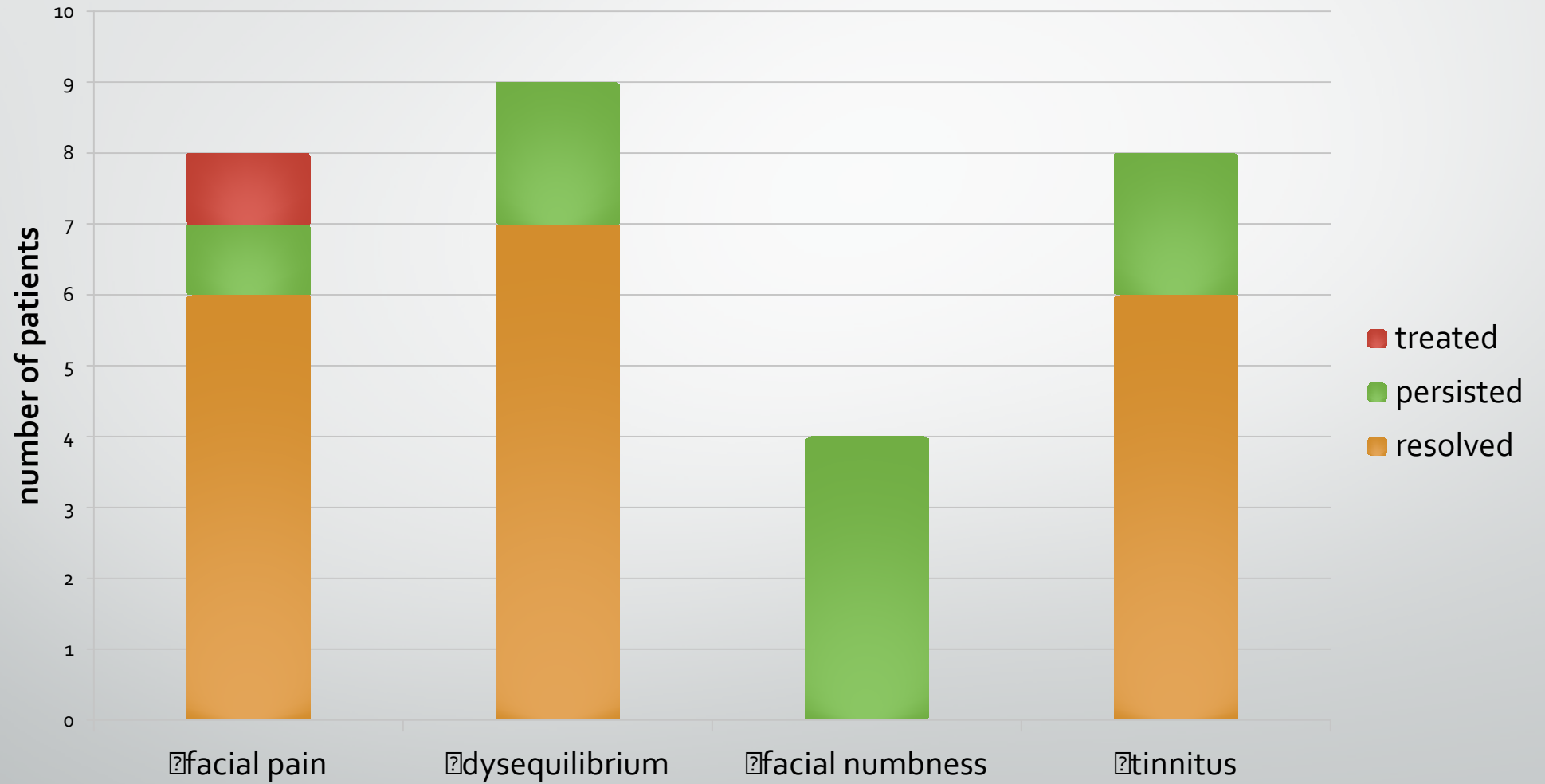


Persistence of symptoms associated with larger tumors initially
5.9 cc vs 9.8 cc ($p=0.003$)

Complications

- Most were mild: steroids required in 3.7% of patients
- Tend to occur at the time of transient tumor increase
- No factor was found predictive of occurrence
- No worsening of motor facial function
- No radiation-induced neoplasia
- VP shunt required in 3 patients for symptomatic hydrocephalus

Evolution of common post treatment adverse events



Conclusions

- Koos grade 4 tumors are not all the same!
- GKRS can be a safe and effective option for Koos grade 4 VS
- Clinical presentation of patients should be the predominant factor in decision-making for these patients, if volume is deemed appropriate

Safety and Efficacy of Gamma Knife Radiosurgery for the Management of Koos Grade 4 Vestibular Schwannomas

Christian Iorio-Morin, MD, PhD*

Fahd AlSubaie, MD, MSc*‡

David Mathieu, MD*

*Neurosurgery Division, Université de Sherbrooke, Centre Hospitalier Universitaire de Sherbrooke, Centre de Recherche du CHUS, Sherbrooke, Quebec, Canada; ‡Saudi National Neuroscience Institute, Riyadh, Saudi Arabia

Correspondence:

David Mathieu, MD,
Division of neurosurgery,
CHUS Hôpital Fleurimont,
3001, 12e Avenue Nord,
Sherbrooke, QC,
J1H 5N4, Canada.
E-mail: david.mathieu@usherbrooke.ca

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WHAT IS THIS BOX?

A QR Code is a matrix barcode readable by QR scanners, mobile phones with cameras, and smartphones. The QR Code above links to Supplemental Digital Content from this article.

BACKGROUND: Gamma Knife radiosurgery (GKRS) is commonly used in treating small vestibular schwannomas; however, its use for larger vestibular schwannomas is still controversial.

OBJECTIVE: To assess the long-term safety and efficacy of treating eligible Koos grade 4 vestibular schwannomas with GKRS.

METHODS: We conducted a single-center, retrospective evaluation of patient undergoing GKRS for Koos grade 4 vestibular schwannomas. We evaluated clinical, imaging, and treatment characteristics and assessed treatment outcome. Inclusion criteria were tumor size of ≥ 4 cm³ and follow-up of at least 6 months. Patients with neurofibromatosis type 2 were excluded. Primary outcomes measured were tumor control rate, hearing and facial function preservation rate, and complications. All possible factors were analyzed to assess clinical significance.

RESULTS: Sixty-eight patients met inclusion criteria. Median follow-up was 47 months (range, 6-125 months). Baseline hearing was serviceable in 60%. Median tumor volume at radiosurgery was 7.4 cm³ (range, 4-19 cm³). The median marginal dose used was 12 Gy at the 50% isodose line. Actuarial tumor control rates were 95% and 92% at 2 and 10 years, respectively. Actuarial serviceable hearing preservation rates were 89% and 49% at 2 and 5 years, respectively. Facial nerve preservation was 100%. Clinical complications included balance disturbance (11%), facial pain (10%), facial numbness (5%), and tinnitus (10%). Most complications were mild and transient. Hydrocephalus occurred in 3 patients, requiring ventriculoperitoneal shunt insertion. Larger tumor size was significantly associated with persisting symptoms post-treatment.

CONCLUSION: Patients with Koos grade 4 vestibular schwannomas and minimal symptoms can be treated safely and effectively with GKRS.

KEY WORDS: Gamma Knife radiosurgery, Hearing preservation, Koos grade 4 vestibular schwannoma, Stereotactic radiosurgery

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Gamma Knife radiosurgery (GKRS) is now a well-recognized primary or adjunctive management option for vestibular schwannomas (VSs) with excellent outcomes.¹⁻³ A recent publication reported a tumor control rate of >96%.⁴ This response rate varies,

depending on tumor size and imaging characteristics. Hearing loss is a recognized complication after radiosurgery, with average hearing preservation rates after treatment of 93% and 87% at 3 and 5 years, respectively.⁴ Baseline hearing and cochlear radiation dose are important factors for hearing preservation.^{5,6}

Tumors with cerebellopontine angle diameter of <3 cm are usually considered suitable for GKRS. However, treatment of larger eligible VSs (cerebellopontine angle diameter between 2 and 3 cm) remains controversial, with some recent works reporting its safety and efficacy.⁷⁻¹¹ Many surgeons still recommend surgical

ABBREVIATIONS: GKRS, Gamma Knife radiosurgery; VS, vestibular schwannoma

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