Leksell Gama Knife

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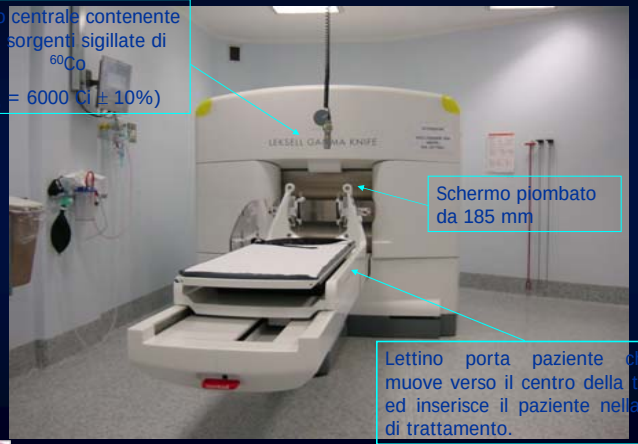
Leksell Gamma Knife

Corpo centrale contenente 201 sorgenti sigillate di ^{60}Co

(A_0 = 6000 Ci ± 10%)



Schermo piombato da 185 mm

Lettino porta paziente che si muove verso il centro della testata ed inserisce il paziente nella zona di trattamento.

Elmetto Collimatore

Le sorgenti sono distribuite lungo un'emisfera in modo che la radiazione converga verso un punto denominato Unit Center Point (isocentro RT)

Nello UCP viene posizionato il bersaglio durante il trattamento.

4 – 8 - 14 - 18 mm

E' possibile trattare volumi anche se di forma irregolare utilizzando isocentri multipli. Dimensione e forma del target possono essere variati combinando tra loro i collimatori o chiudendone una parte.

La peculiare struttura della GK permette di strutturare l'isodose di riferimento (50%) esattamente attorno al target *con un coinvolgimento estremamente limitato delle strutture sane circostanti.*

Sistema Stereotassico

1. un casco che viene fissato alla teca cranica del paziente per mezzo di quattro viti
2. una sfera di materiale plastico che viene fissata al casco e permette di misurare l'encefalo
3. un set di localizzatori da scegliere in base alla metodologia diagnostica prescelta (TC, RM, DSA)

1

2

3

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TP

Dopo aver eseguito l'indagine diagnostica, le immagini vengono inviate al

Gamma Plan

per l'elaborazione del piano di trattamento.

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QA program

- **Emergency tests (initialising, alarm, interlock) to check safety and security of the machine for patients and workers**
- **Tests on acquisition and transfer of the CT and MR images**
- **Dosimetric tests (dose-rate, dose profiles, dose-response linearity, output factors)**
- **mechanical and geometrical tests (timer accuracy, precision of beam alignment, focus precision check, accuracy of geometrical center and irradiation center)**

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IMAGING

Ogni 6 mesi**, controllo del sistema di trasferimento ed elaborazione delle immagini con**

ELEKTA MR PHANTOM

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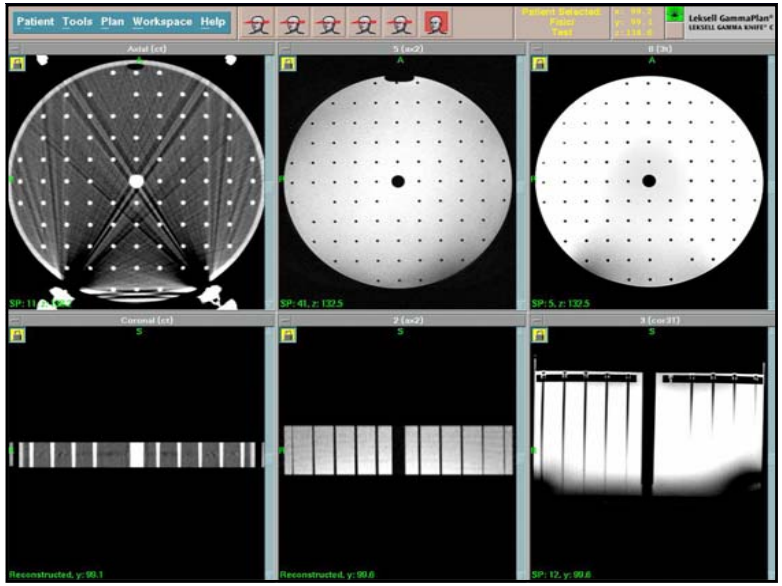
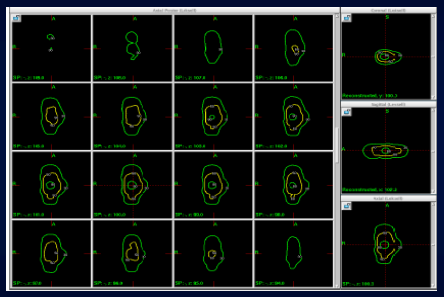


To check the correct working of collimators we simulated a treatment setting all different collimators. We then irradiated a head phantom with gaf chromic films inside



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Parameter	Tolerance	Frequency
dose rate	**± 2%**	**monthly**
complex treatment reproducibility	**DD < ± 2% Dd in progress**	**monthly**
timer accuracy	**< 0.07 min**	**monthly**
distorsion and resolution	**1 mm axial 2 mm coronal**	**two-yearly**
output factors	**± 3 % (16 mm), ± 3 % (8 mm), ± 5 % (4 mm)**	**two-yearly**
accuracy of geometrical and irradiation center	**+ 0.5 mm**	**two-yearly**
dose profiles of all collimators on x, y, z axis	**± 1 mm**	**yearly**
dose-response linearity	**± 2%**	**yearly**

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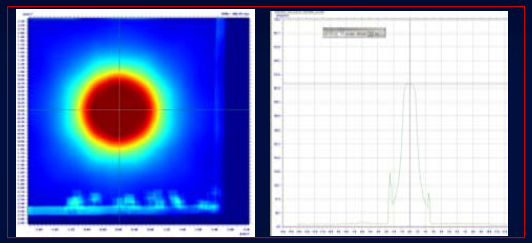

2D dose distribution from a gaf chromic for the 16 mm collimator in xy plane and the correspondent profile

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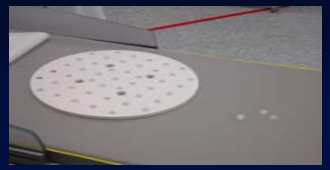
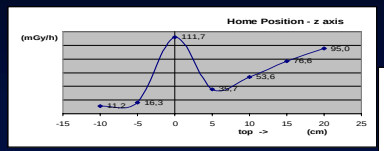
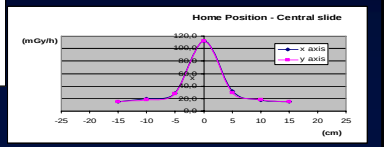
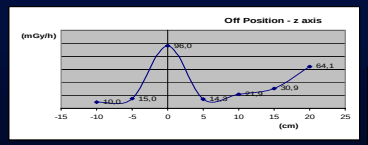
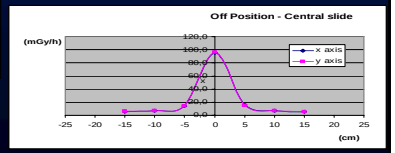
- The stray radiation field inside the radiation unit of Leksell GammaKnife® Perfexion™ has been measured using a custom made holder (Fig. 1) for Thermo Luminescent Dosimeters.
- 257 TLD (type GR200A, LiF: Mg,Cu, chip Ø 4,5 x 0.8 mm, Sensitivity 0,5 µGy - 12 Gy, Reader type RADOS RE-2000)
- were placed on a holder made of paper and Styrofoam with an estimated resolution accuracy of 5 mm; every single TLD-chip was placed in a special box to obtain the build-up condition.
- Calibration of the TLD-chips were performed at CESNEF centre of Politecnico University – Milan (Italy), using an ICRU-ISO Slab 300X300X150 phantom, with an ISO Co-60 beam. In this way the measured values correspond to Hp(10).





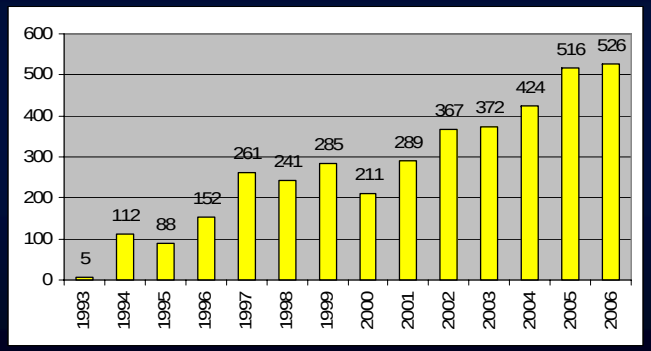






Stray field is “flowing” through the collimators in the direction of the focus point. The magnitude of the field – measured as Hp(10) - is approximately 2 mGy/min when the sectors are either in sector Off or sector Home position. The field is slightly higher when the sectors are in Home position due to the fact that the treatment cavity is less effectively shielded from the sources at the very back on the sectors when the sectors are in the Home position. The magnitude of this stray field, and the assumption that this field has no, or at least a very low, clinical significance.

Attività Gamma Knife hSR (1993 – 2006)



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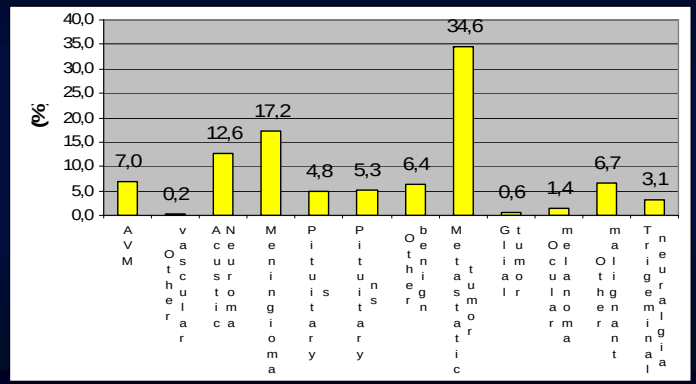
hSR : Patologie trattate (2001 – 2006)



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Dosi per patologia (50%)

	dose media	dose massima	dose minima
Adenoma NS	18	22	14
Adenoma S	25	25	24
MAV	22	30	18
Melanoma uveale	35		
Meningioma	14	24	9
MET	22	33	10
Neurinoma acustico	13	15	10
Nev. Trigemino	40		

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Dosi massime consigliate (Gy)

Nervo ottico e chiasma	8	
	6	Se precedente RT
	10	Dmax tollerata
	12	20-30% cecità post trattamento
Nervi cranici oculomotori	15	
Trigemino	12	Con 13-14 Gy, 1-3% complicanze
Acustico	13	50% deterioramento
Coclea	8	Ipoacusia
Brain sterm	14-15	Per piccoli volumi o interfaccia
	10	Per grandi volumi
Ipofisi	15	Ipopituitarismo
Stalk	8	Ipopituitarismo
Cristallino	1	Cataratta con D > 5 Gy
Area motoria	15	
Cute	10	Alopecia
	20	Necrosi

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Radiochirurgia per Adenomi NS

Radiosurgery Practice Guideline Initiative

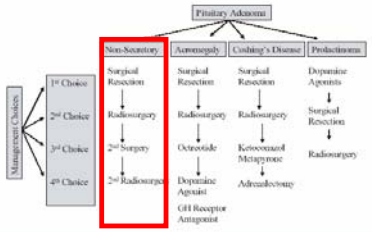
Stereotactic Radiosurgery for Patients with Pituitary Adenomas

Practice Guideline Report #3-04

ORIGINAL GUIDELINE: April 2004
MOST RECENT LITERATURE SEARCH: April 2004

This practice guideline, together with a report on "Pituitary Tumors: Overview" is an original guideline approved by the IRSA® (International RadioSurgery Association) Board of Directors and issued in April 2004.

Management Choices for Pituitary Adenomas



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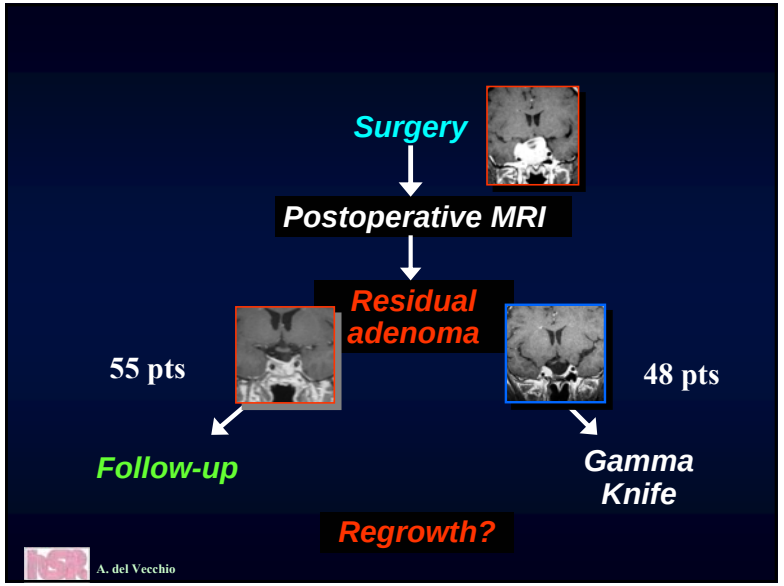

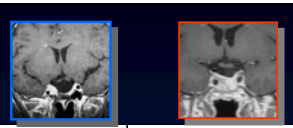

	GKRS group	No GKRS group
Patients N°	48	55
males	24	34
females	24	21
Mean age	55±2 yrs	52±2 yrs
Mean follow-up	40.5±3.4 months	63.7±5.3 months
Volume cm^3	2.5±0.3	3.1±0.4

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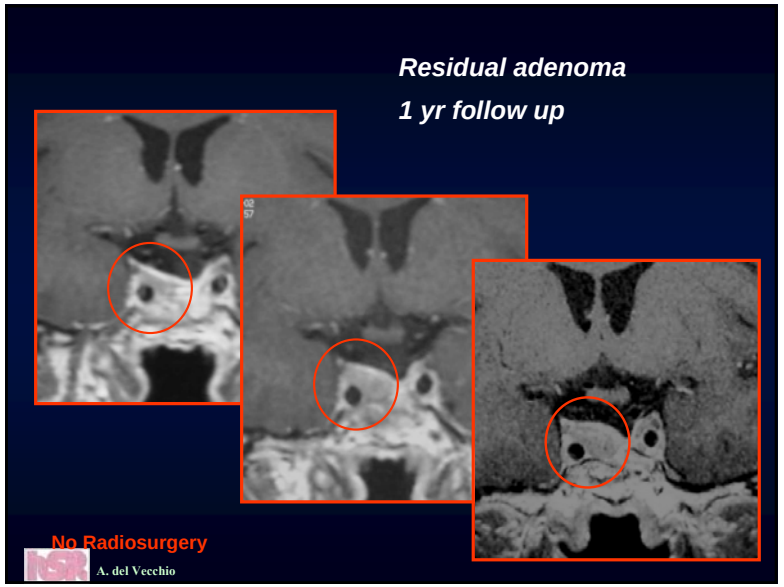

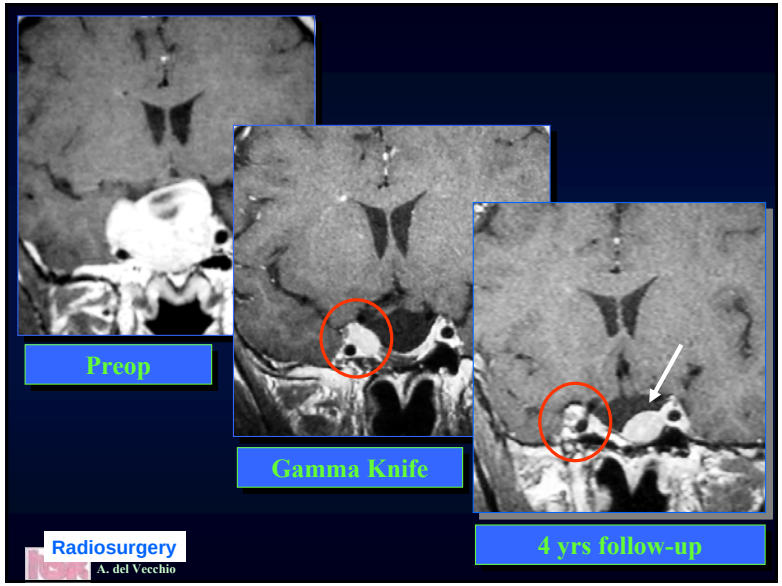

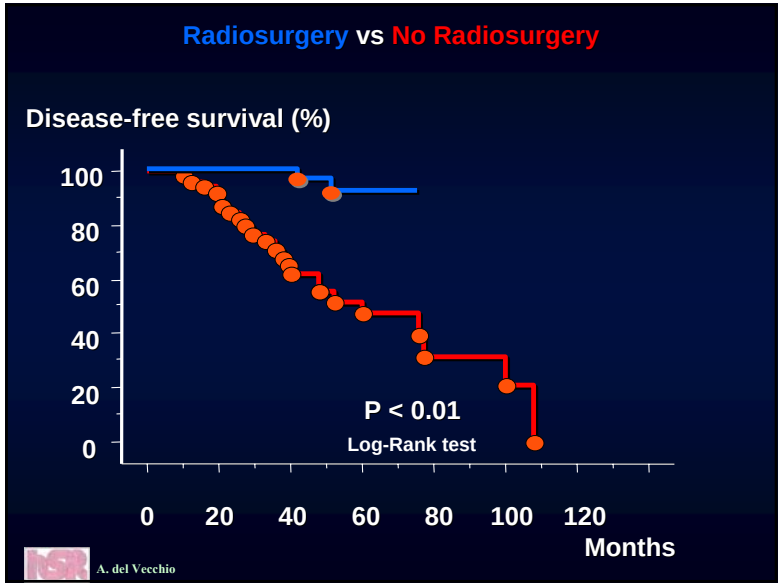

Radiochirurgia per MAV

Definizione (Steiner e Lindquist)

Una MAV è considerata completamente chiusa (obliterazione completa), quando un'angiografia effettuata entro 3 anni dal trattamento dimostra la completa assenza di vasi patologici, la scomparsa/normalizzazione del drenaggio venoso della zona, la normalizzazione del circolo nei tempi venosi e arteriosi.

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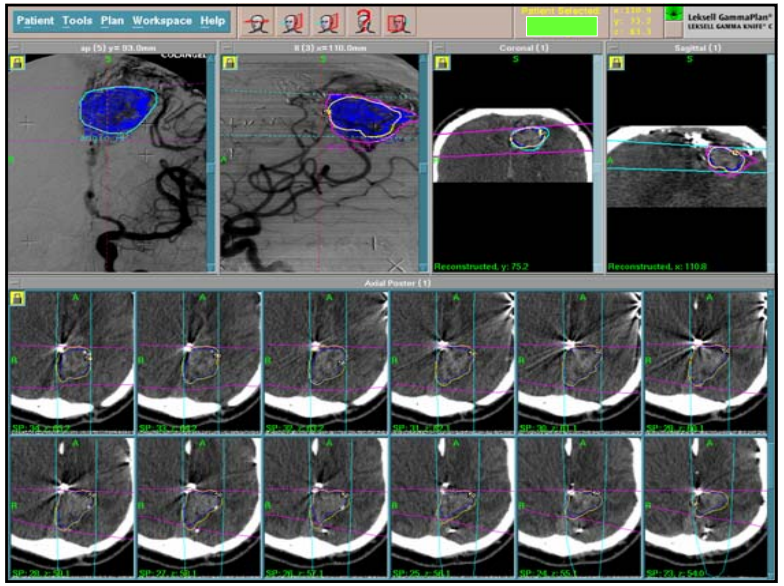


Modelli previsionali

1. **K index**

$$P_{obl} = 3.073 * (D_{min}) * (V_{MAV})^{1/3} - 3.385$$
$$1 \le \sqrt[3]{VOL} \le 2$$
$$0\% \le P_{obl} \le 80\%$$

2. **Karlsson-Lax**

$$P_{obl} = 35.69 * \ln(D_{min}) - 39.66$$

3. **Schwartz**

$$P_{obl} = 100 * (1 - 1.15 * e^{-0.11 * D_{min}/d})$$

4. **Flickinger**

$$P_{obl} = 100$$
$$D_{min} > 35Gy$$

Probabilità di danno - 1

Karolinska

$$P(D,v) = 1 - \prod [1 - \exp(-N_0 \exp(-D_i / D_0))]^{\Delta v_i}$$

Ok fino a 20 Gy in 20 cc

MAV divise in 3 classi

Probabilità di danno - 2

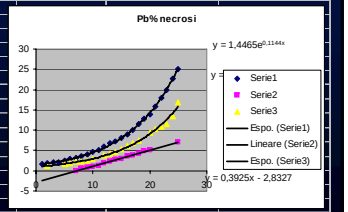
Pittsburgh

- **Localizzazione della MAV**
- **V che riceve D>12 Gy**
- **Età**

Dose	Anni Pz	V(MAV)	Dmedia(20cc)	V(12 Gy)	Tipo MAV (1=C;2=PS;3=PNS)	Pb% necrosi	Pb% obliterazione	Pb% sanguinamento
22,0	25	2,100	9,0	8,900	1	4,05	70,66	1,465
21,0	25	2,100	8,6		1	3,86	69,00	1,610
20,0	25	2,100	8,2		1	3,69	67,26	1,761
24,0	25	2,100	9,8		1	4,45	73,76	1,198
25,0	25	2,100	10,2		1	4,66	75,22	1,076
23,0	25	2,100	9,4		1	4,24	72,25	1,328

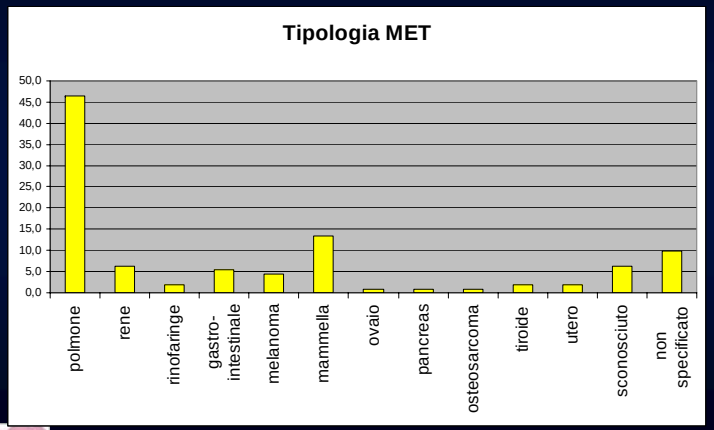
Attenzione la dose media in 20 cc si calcola come dose media su una maschera centrata sulla MAV con griglia 0,5

Nome paziente:



Modello Karlsson - Lax

Radiochirurgia per Metastasi



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- **Single session**
- **Peripheral dose** 20 - 25 Gy
- **Lesion Ø ≤ 3 cm (volume 15 cm³) or total tumor volume in multiple Mets ≤ 20 cm³**

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- Prognosi
- N° Metastasi
- Istologia

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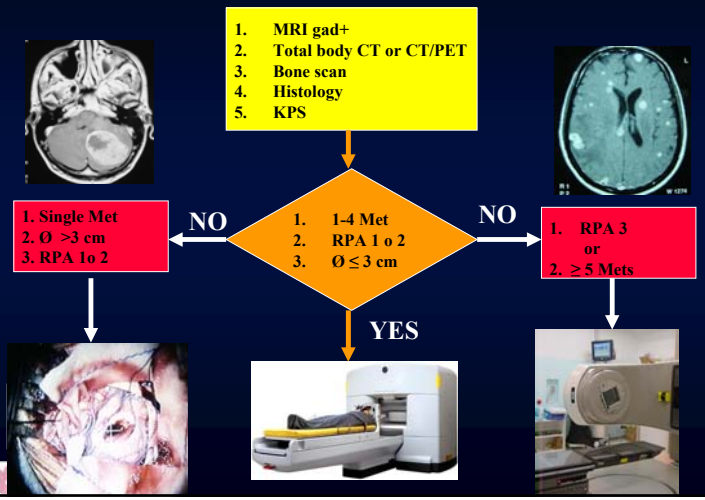
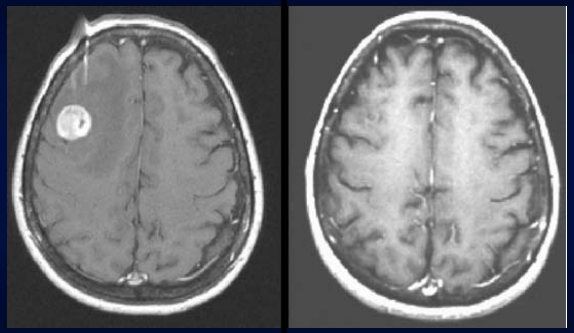
Cerebral metastases



Cerebral Metastases Radiosurgery



GK radiosurgery

10-month follow-up

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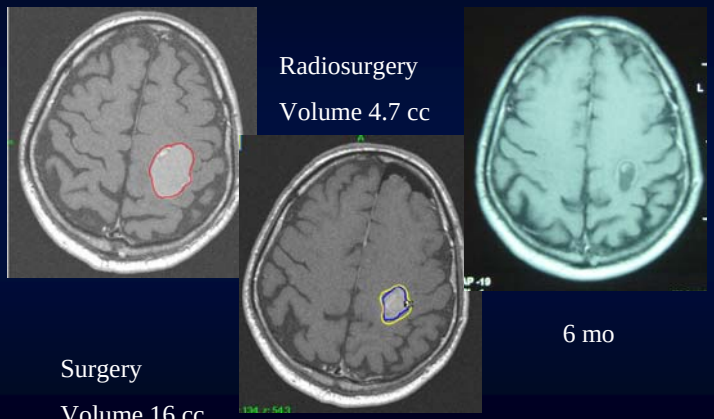
Surgery+RS in cystic metastases



Radiosurgery

Volume 4.7 cc

Surgery

Volume 16 cc

6 mo

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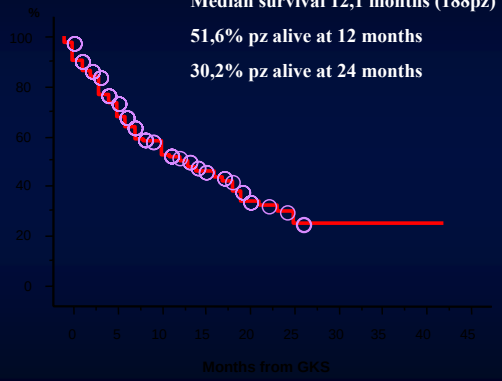
Survival

Median survival 12,1 months (188pz)

51,6% pz alive at 12 months

30,2% pz alive at 24 months



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Risultati

Controllo locale ad 1 anno: 89%

Complicanze

Radionecrosi, edema 8,6 %*

*In 2 pz surgical removal of the necrotic lesion

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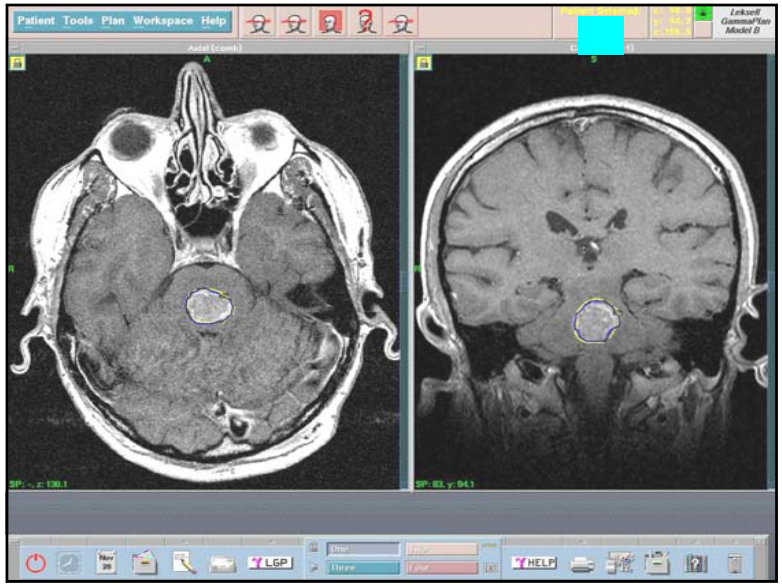

Local Recurrences of the treated Metasteses

	1-year local recurrence
Radiosurgery	11%
Surgery	46%
WBRT	80- 100%
Surgery + WBRT	10%

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Mortality

	Mortality
Radiosurgery	0%
Surgery	2-8%
WBRT	0%
Surgery + WBRT	2-8%

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Follow up and salvage therapy GK o WBRT ?

1-4 new mets
Primary controlled
KPS>70

Yes

MRI: every
3 months

New mets
?

Yes

>5 mets
Primary
non controlled
KPS<70

Follow-up

NO

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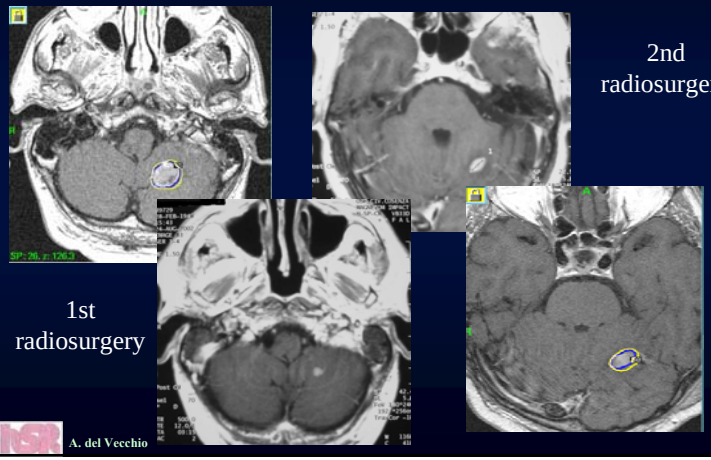
Salvage Therapy: 2nd Radiosurgery



2nd radiosurgery

1st radiosurgery

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51 Yrs m: NSCLC. RPA1 controlled primary

- **3/12/1999: GK 3 mets**
- **19/6/2000: GK 2 mets**
- **5/3/2001: GK 1 met**
- **1/2/2003: GK 3 mets (1 recurrent)**
- **23/10/2003: GK 2 mets**
- **May 2004: 8 mets> WBTR**

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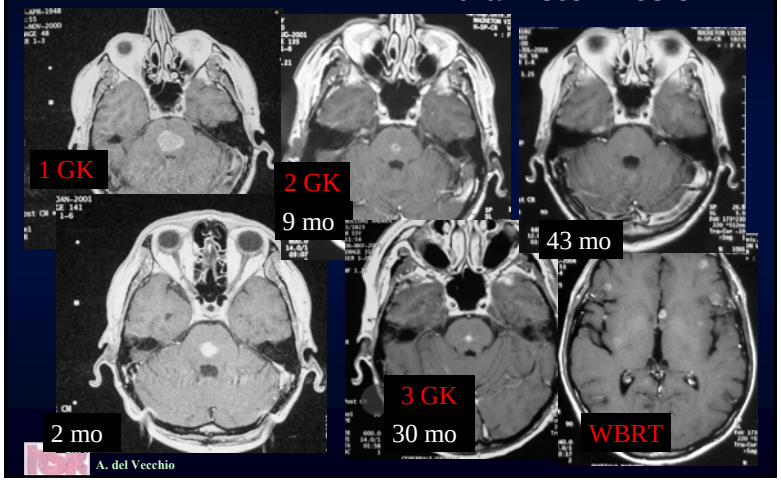
Gamma Knife Radiosurgery: brain stem lesion



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Trattamenti frazionati

20 patients have been treated in 3 fractions between Jan 2006 and Dec 2007 spaced out 24 hours each In all cases the most critical situation was the irradiation of chiasm and/or optical nerve. Three patients were previously treated with GK (2) or RT (1), so they presented the additional problem of taking into account accumulated doses.

PATHOLOGY	n PATIENTS
NEUROMA	2
MENINGIOMA	14
GLIOMA	1
ENDOCRANIC RELAPSES (k rinopharinx)	3

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TUMOURS	a/b RATIOS
NEUROMA	2
MENINGIOMA	3.3
OTHERS MALIGNANT	10

ORGANS AT RISK	a/b RATIOS
OPTICAL PATH	2
BRAIN STEAM	3.3
CHIASM	2

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Although the use of the linear quadratic model in stereotactic radiosurgery has some limits, at present time, no patients have presented secondary effects due to irradiation, even if delivered doses are higher than our normal single fraction constraints. Our calculation model overestimates the doses at OARs, as it doesn't take into account cellular repopulation during the interval time.

ORGANS	a/b	number of fractions	Prescribed dose/fraction [Gy]	BED	EqD (2Gy)	Dsf
TARGET	3.3	3	7	65.5	41	13.1
OPTICAL NERVE	2	3	8.2	125.5	63	14.9
CHIASM	2	3	6.8	89.8	45	12.4
BRAIN STEM	3.3	3	7.9	80.4	50	14.7
SKULL	3	3	11.3	161.6	97	20.6

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- **The median follow-up was 12 months. Visual acuity improved in one patient (7.1%); one patient had improved visual field (7.1%). No patient had visual deterioration.**
- **Tumor volumetric reduction was observed in 5 patients (35.7%), whereas in 9 patients (64.3%) no volumetric variation was recorded.**

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clinical results after fractionated gamma knife radiosurgery

- **Mean pre-treatment volume 4.23 cm3 (3.3 cm3/ 0.33-8.1)**
- **Mean prescription dose/session 6.9 ± 0.1 Gy (7/ 6.5-7)**
- **Mean total prescription dose 20.7 (19.5-21 Gy).**
- **Mean follow-up (median/range) 18 months (19/7-71)**
- **Post-treatment visual acuity outcome**
  - **Improved 2**
  - **Worsened 0**
  - **Stable 12**
- Local tumor control
  - Reduction 5
  - Progression 0
  - Stable 9
- Cranial nerves function
  - Improved 1
  - Worsened 0
  - Stable 13

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- **Patrizia Signorotto**
- **Giovanni Mauro Cattaneo**
- **Lucia Perna**
- **Paola Mangili**
- **Piero Picozzi**
- **Alberto Franzin**

Conclusioni

La Radiochirurgia Stereotassica Mediante GK, ha dato nel tempo risultati superiori alle aspettative, ma :

• Importante lavoro d'EQUIPE : Neurochirurgo – Neurologo – Radioterapista – Fisico

• Importante parco macchine per diagnostica

• Controlli di qualità accurati e precisi

• Aperto lo studio delle dosi agli organi critici nei ritrattamenti e nei frazionamenti