Gamma Knife Tabanlı Intracranial SRS
- II-

Ana Başlıklar

1-SRS tedavilerinde Gamma knife üstün sabitleme sistemine sahiptir.

2-Linac tabanlı SRS cihazlarında mekanik doğruluğun GK ile karşılaştırılması

3-Intracranial SRS uygulamaları tek fraksiyone tedavilerdir.

4-Çoklu metastazların tedavisinde SRS tedavileri için üç cihazdan hangisi en iyi çözüm olabilir?

5-Intracranial SRS tedavilerinde homojenite indexi önemli bir parametre midir?

1-SRS tedavilerinde Gamma knife üstün sabitleme sistemine sahiptir.

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Gamma Knife-Frame Based SRS

Doğruluk, Kesinlik (Accuracy) :

- Hedef stereotaktik çerçeve ile sabit hale getirilir
- Tedavi ve görüntüleme sırasında hedef <0.2mm hareket
- Tedavinin doğruluğundan emin olunur
- Hassas nörocerrahi için çerçeve standarttır.

Int. J. Radiation Oncology Biol. Phys., Vol. 55, No. 5, pp. 1400–1408, 2003

0360-3016/03/$–see front matter

ELSEVIER

doi:10.1016/S0360-3016(02)04597-2

PHYSICS CONTRIBUTION

PATTERNS OF PATIENT MOVEMENT DURING FRAMELESS IMAGE-GUIDED RADIOSURGERY

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QUYNH-THU LE, M.D.,* JENNY HAI, PH.D.,* DANIEL KIM, M.D.,† DAVID P. MARTIN, M.D.,† AND
JOHN R. ADLER, JR., M.D.†

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Purpose: Image-guided radiosurgery aligns the treatment beam to the target site by using a radiographic imaging system to locate anatomic landmarks associated with the treatment target. Because the procedure is performed without a rigid frame, the precision of dose alignment can be affected by patient movement. Movement is limited by noninvasive restraints and compensated by remeasuring the target position at short intervals throughout treatment and then realigning the beam. Frameless image-guided radiosurgery has been used at our institution to treat 250 cranial, 23 spinal, 9 lung, and 3 pancreas cases involving malignant and benign tumors as well as vascular malformations. We have analyzed the target position records for all of these cases to assess the frequency, magnitude, and case-by-case patterns of patient movement.

Maske ile (Çerçevesiz) SRS uygulanan hastanın tedavi sırasındaki hareketi incelendiğinde:

- Kafa hareketi kısıtlı ama elemine edilemedi
- Hedefin hareket etme olasılığı hep var
- 1.5 dak. ara ile pozisyon doğruluğu izlendi

Maske ile SRS uygulanan hastanın tedavi sırasındaki hareketi incelendiğinde:

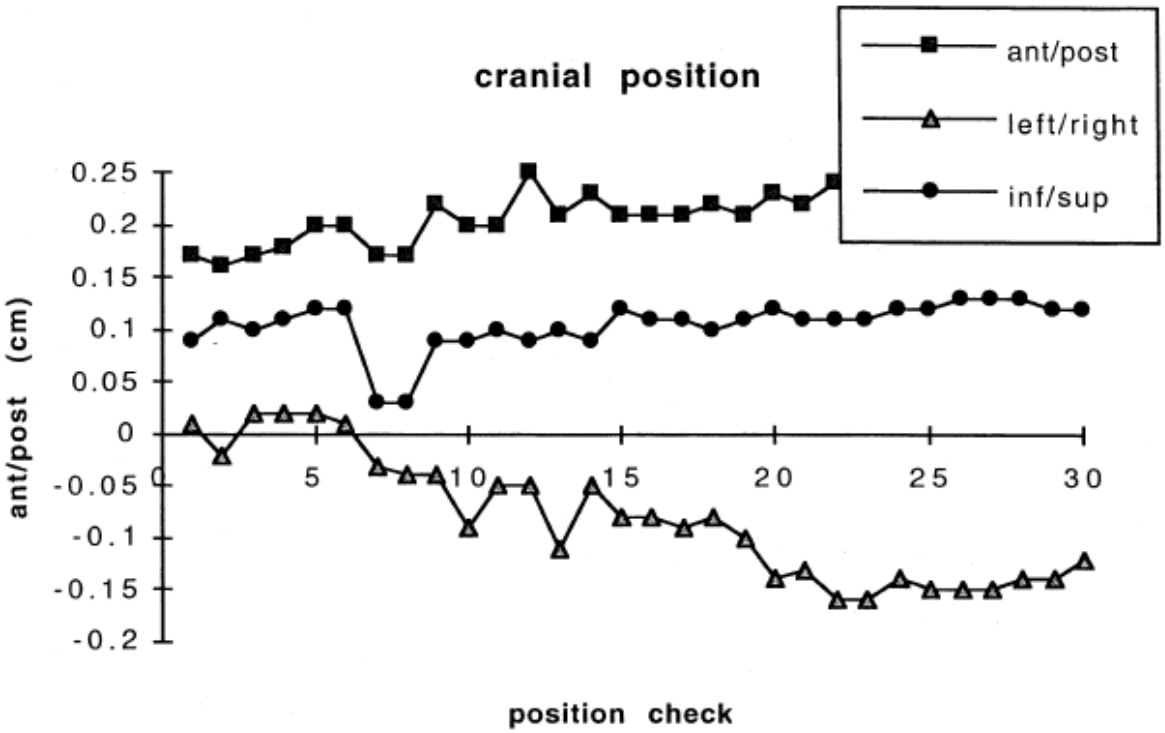


Fig. 3. A record of the position (in cm) over time of a cranial treatment site. The position checks were made at approximately 1.5-min intervals.

- 146/ 250 hastada (%58) shift>2mm
- Bir hasta hareket nedeni ile iptal

PHYSICS CONTRIBUTION

INTER- AND INTRAFRACTION PATIENT POSITIONING UNCERTAINTIES FOR INTRACRANIAL RADIOTHERAPY: A STUDY OF FOUR FRAMELESS, THERMOPLASTIC MASK-BASED IMMOBILIZATION STRATEGIES USING DAILY CONE-BEAM CT

ERIK TRYGGESTAD, PH.D.,* MATTHEW CHRISTIAN, B.A.,† ERIC FORD, PH.D.,* CARMEN KUT, B.S.,‡ YI LE, PH.D.,* GIUSEPPE SANGUINETI, M.D.,* DANNY Y. SONG, M.D.,* AND LAWRENCE KLEINBERG, M.D.*

*Department of Radiation Oncology and Molecular Radiation Sciences, Johns Hopkins University, School of Medicine, Baltimore, MD; †University of Maryland, School of Medicine, Baltimore, MD; and ‡Johns Hopkins University, School of Medicine, Baltimore, MD

Purpose: To determine whether frameless thermoplastic mask-based immobilization is adequate for image-guided cranial radiosurgery.

Methods and Materials: Cone-beam CT localization data from patients with intracranial tumors were studied using daily pre- and posttreatment scans. The systems studied were (*1*) Type-S IMRT (head only) mask (Civco) with head cushion; (*2*) Uni-Frame mask (Civco) with head cushion, coupled with a BlueBag body immobilizer (Medical Intelligence); (*3*) Type-S head and shoulder mask with head and shoulder cushion (Civco); (*4*) same as previous, coupled with a mouthpiece. The comparative metrics were translational shift magnitude and average rotation an-

121 hasta,
Tedavi öncesi ve sonrasında CBCT çekilerek 4 ayrı immobilizasyon sistemi için intra ve interfraksiyon hasta pozisyonundaki değişimler
1-TypeS (head) maske, hastaya özel şekillendirilmiş yastık
2-Uniframe maske hastaya özel vakumlu yatak ve yastık
3-Type-S (head+sholder), hastaya özel kafa ve omuz yastığı
4- Ağız sabitleyici ilave edilerek

Tryggestad, IJROBP 80, 2011 P281

CBCT ile Tedavi sırasında ve tedaviler arasındaki pozisyon değişimi

•Mean 3D interfraction motion (mm):

immob 1: 2.3 (+/-1.4)
immob 2: 2.2 (+/-1.1)
immob 3: 2.7 (+/-1.5)
immob 4: 2.1 (+/-1.0)

•Mean 3D intrafraction motion (mm):

immob 1: 1.1 (+/-1.2)
immob 2: 1.1 (+/-1.1)
immob 3: 0.7 (+/-0.9)
immob 4: 0.7 (+/-0.8)
•Rotations: 1^0, 1.4^0

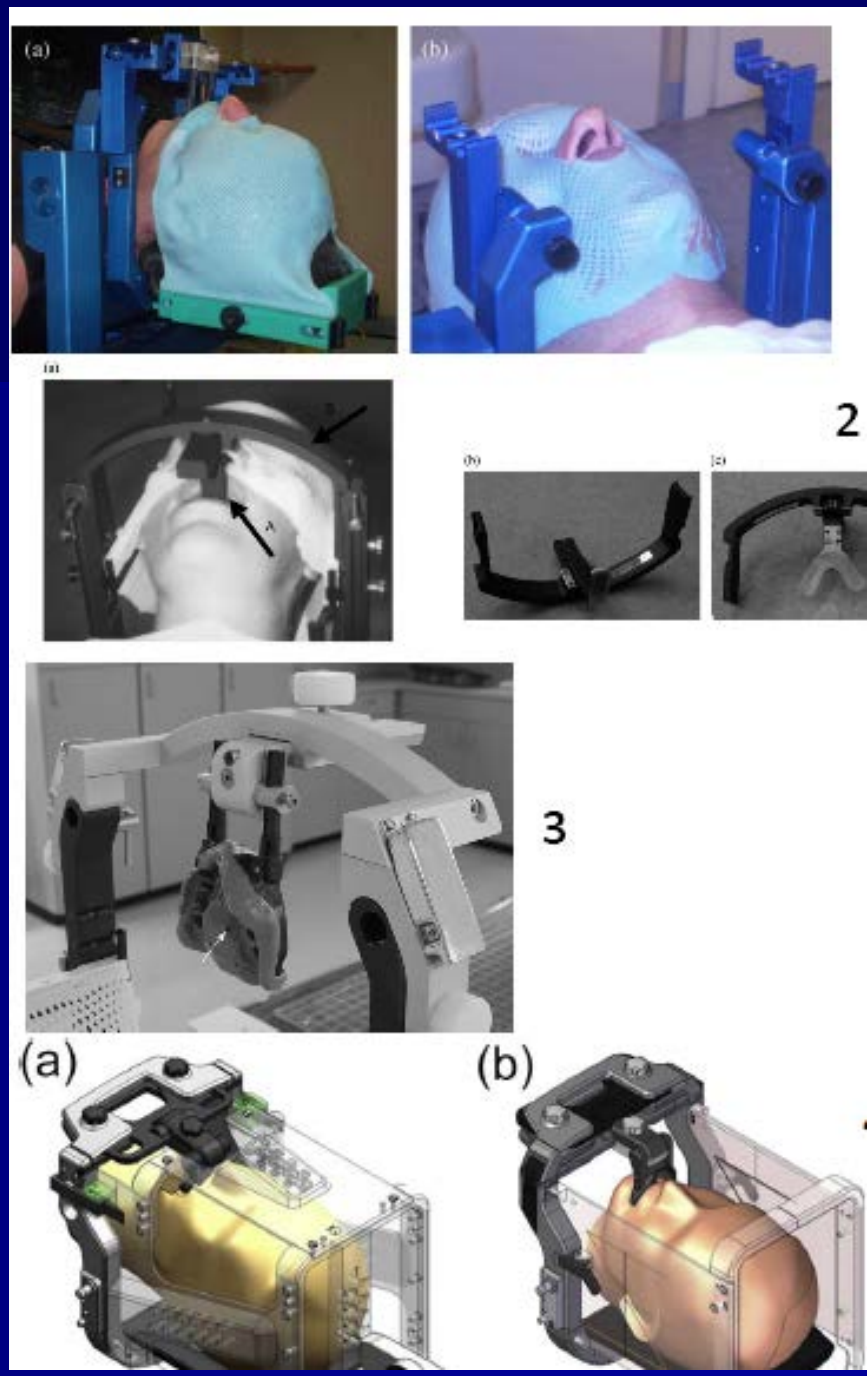
MASKE İLE SABİTLEME

1-Masi, IJROBP 71, 2008 p926
(3D: 3.2 +/-1.5 mm ve 2.9 +/- 1.3 mm (bite block) and rotasyon: -1.0 ^{0}+/- 1.6, -0.8 ^{0} +/- 1.0 ^{0} , -0.1^{0} +/- 1.2^{0} tedavi uzadıkça hata artma eğiliminde (15 min). Bite blok azaltır.

2-Baumert, R&O 74, 2005 p61:
3D: 3.7 +/- 2.8 mm ve 2.2 +/- 1.1 mm (bite-block, ile $p<0.001$)

3-Santvoort IJROBP 72, 2008 p261
Brainlab mask ortalama 3D: 2.1 +/- 1.2mm ve1.7 +/- 0.7mm bite block

4-Ruschin IJROBP 79, 2010 p306
Gamma-Knife bite block accuracy:
average 3D: 2.0 mm +/- 1.1 mm



Maske ile Sabitleme Sistemlerin Doğruluğu 3D-3D ve Ortogonal X-Ray

Study	Immobilization system	Imaging modality	Intrafractional error 3D vector
Boda-Heggemann 2006	Thermoplastic masks Scotch cast mask	Cone-beam CT	**1.8mm ± 0.7mm** **1.3mm ± 1.4mm**
Masi 2008	Thermoplastic mask & Bite block Bite-block	Cone-beam CT	**< 1mm** **< 1mm**
Lamda 2009	BrainLab mask	Orthogonal x-rays	**0.5mm ± 0.3mm**
Ramakrishna 2010	BrainLab mask	Orthogonal x-rays	**0.7mm ± 0.5mm**
Guckenberger 2010	Scotch cast mask Thermoplastic masks	Cone-beam CT	**0.8mm ± 0.4mm** **0.8mm ± 0.5mm**

SBRT set up

Radiotherapy and Oncology 95 (2010) 109–115

A clinical comparison of patient setup and intra-fraction motion using frame-based radiosurgery versus a frameless image-guided radiosurgery system for intracranial lesions

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ARTICLE INFO

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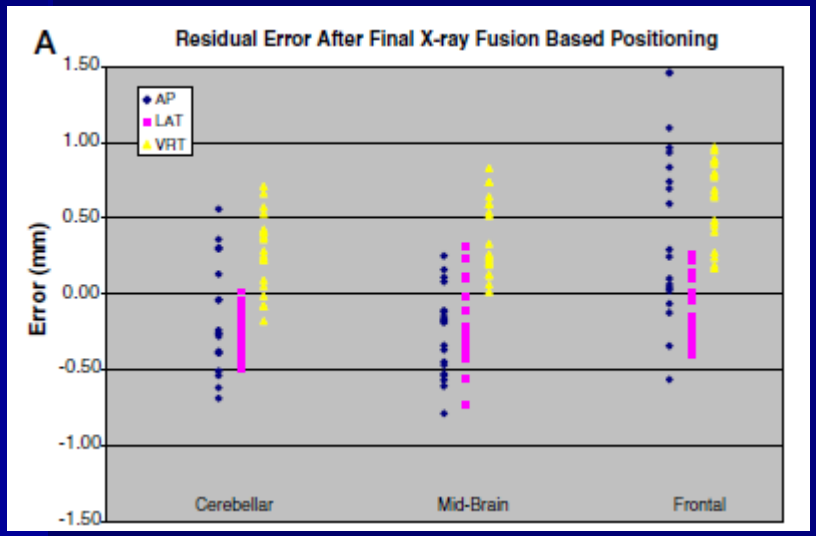
Frameless

ABSTRACT

Background and purpose: A comparison of patient positioning and intra-fraction motion using invasive frame-based radiosurgery with a frameless X-ray image-guided system utilizing a thermoplastic mask for immobilization.

Materials and methods: Overall system accuracy was determined using 57 hidden-target tests. Positioning agreement between invasive frame-based setup and image-guided (IG) setup, and intra-fraction displacement, was evaluated for 102 frame-based SRS treatments. Pre and post-treatment imaging was also acquired for 7 patients (110 treatments) immobilized with an aquaplast mask receiving fractionated IG treatment.



1-SRS tedavilerinde Gamma knife üstün sabitleme sistemine sahiptir.

2-Linac tabanlı SRS cihazlarında mekanik doğruluğun GK ile karşılaştırılması

3-Intracranial SRS uygulamaları tek fraksiyone tedavilerdir.

4-Çoklu metastazların tedavisinde SRS tedavileri için üç cihazdan hangisi en iyi çözüm olabilir?

5-Intracranial SRS tedavilerinde homojenite indexi önemli bir parametre midir?

Accuracy and stability of positioning in radiosurgery: Long term results of the Gamma Knife system

Bernhard Heck[a)] and Anja Jess-Hempen
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Hans Jürg Kreiner
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Gamma Knife Frankfurt, Schleusenweg 2-16, 60528 Frankfurt

(Received 19 July 2006; revised 31 January 2007; accepted for publication 31 January 2007; published 27 March 2007)

Gamma Knife'ın uzun dönem pozisyon doğruluğunun kontrolu:
2kez / 10yıl Özel fantom+Gaf Cromic film

Frame-based SRS Pozisyon Doğruluğu

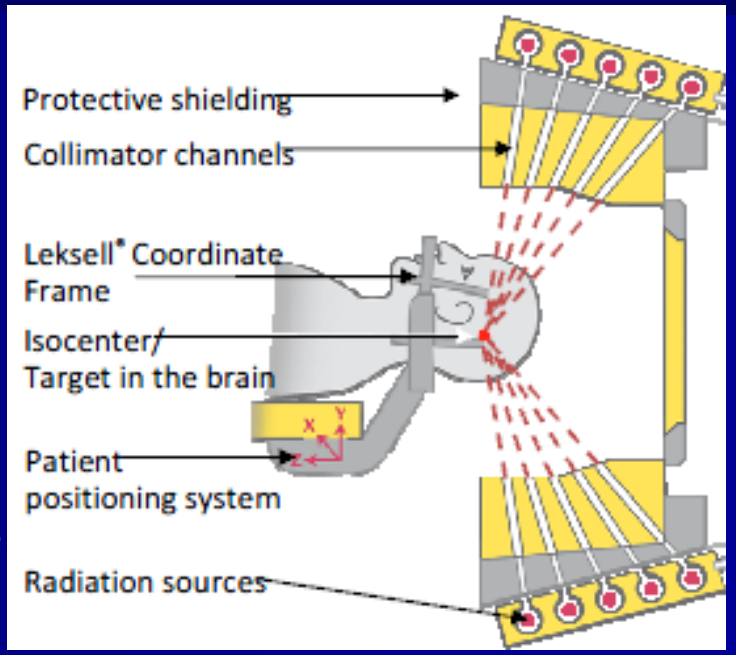
GrafChromic film ölçümü:

X: - 0.014+/- 0.09mm

Y: 0.013+/- 0.09mm

Z: - 0.002+/- 0.06mm

Bütün ölçümler **0.2mm** yarıçaplı daire içinde



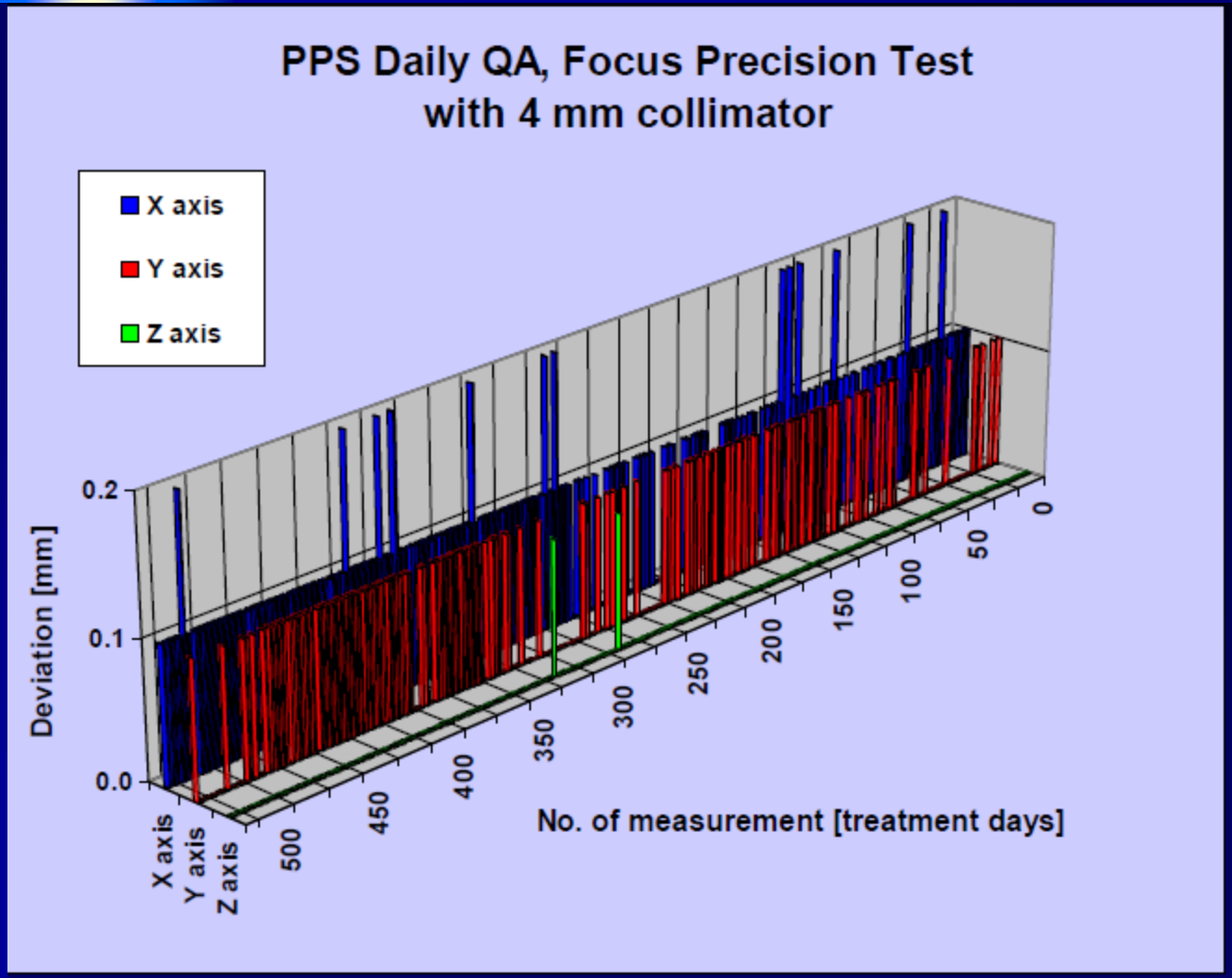
CT-based target tanımlanması

X: 0.06+/-0.09mm

Y: 0.04+/-0.09mm

Med Phys 2007 Apr; 34(4): 1487-95

Perfexion-HPS Günlük QA cihazı Test



$\Delta X = 0.1 \pm 0.1$ mm

$\Delta Y = 0.0 \pm 0.0$ mm

$\Delta Z = 0.0 \pm 0.0$ mm

RADIAL $= 0.1 \pm 0.1$ mm

JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 13, NUMBER 4, 2012

Imaging system QA of a medical accelerator, Novalis Tx, for IGRT per TG 142: our 1 year experience

Zheng Chang,[a] James Bowsher, Jing Cai, Sua Yoo, Zhiheng Wang, Justus Adamson, Lei Ren, and Fang-Fang Yin
Department of Radiation Oncology, Duke University, Durham, North Carolina, 27710, USA
zheng.chang@duke.edu

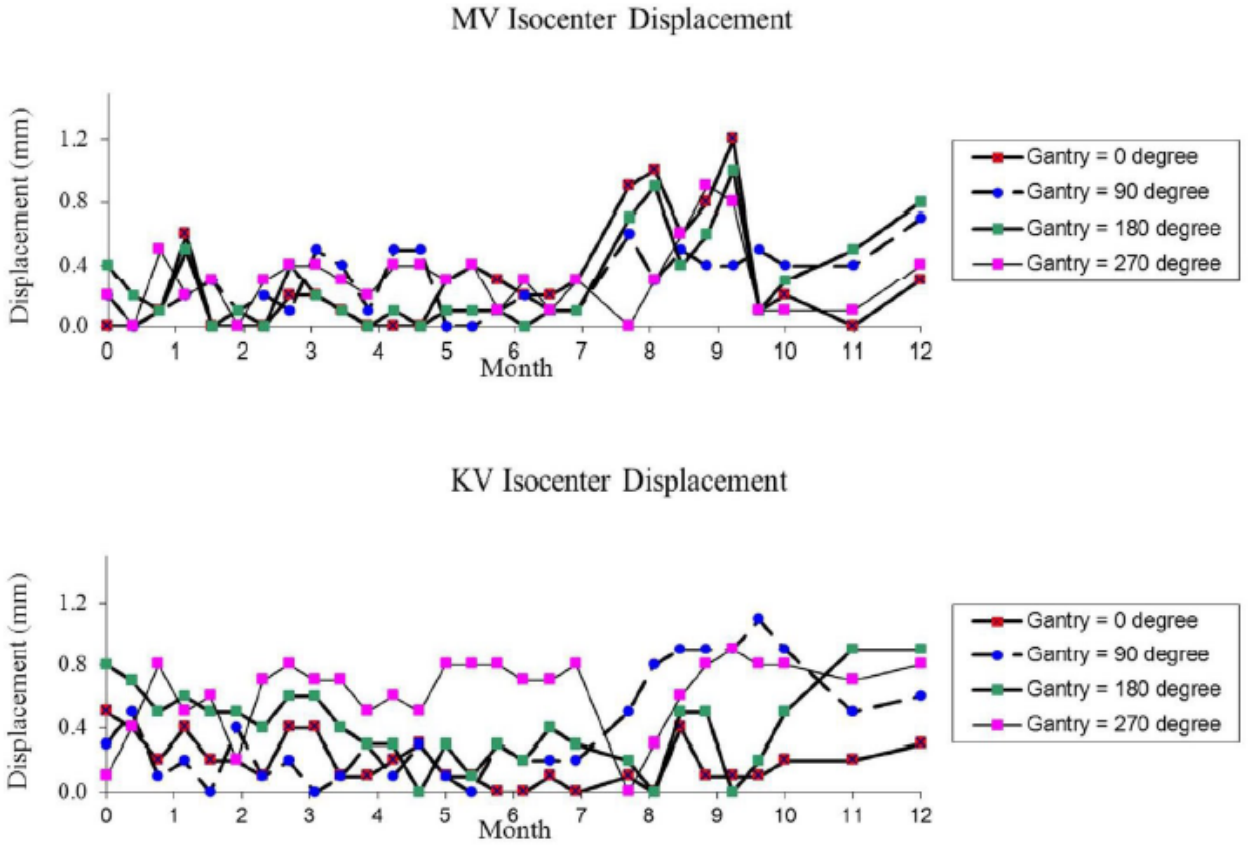


Fig. 9. Results of the 29 measurements of the QA of Imaging & Treatment Coordinate Coincidence over a period of 12 months: MV PV imaging isocenter accuracy (top) and KV OBI imaging isocenter accuracy (bottom). The vector displacement was measured between the center of the digital graticule and the center marker in the image.

Mekanik Doğruluk ve Toplam Tedavi Doğruluğu Fantom Ölçümleri

	Mechanical accuracy	Overall treatment accuracy
Gamma Knife Perfexion♮	0.30 mm	0.93 mm
Dedicated Linac: Novalis	0.31 mm	0.50 – 1.5 mm
Cyberknife*	0.50 mm	0.85 mm

* Hoogeman 2008 & Murphy 2009
♮ Wu & Maitz & Massagier 2007

1-SRS tedavilerinde Gamma knife üstün sabitleme sistemine sahiptir.

2-Linac tabanlı SRS cihazlarında mekanik doğruluğun GK ile karşılaştırılması

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4-Çoklu metastazların tedavisinde SRS tedavileri için üç cihazdan hangisi en iyi çözüm olabilir?

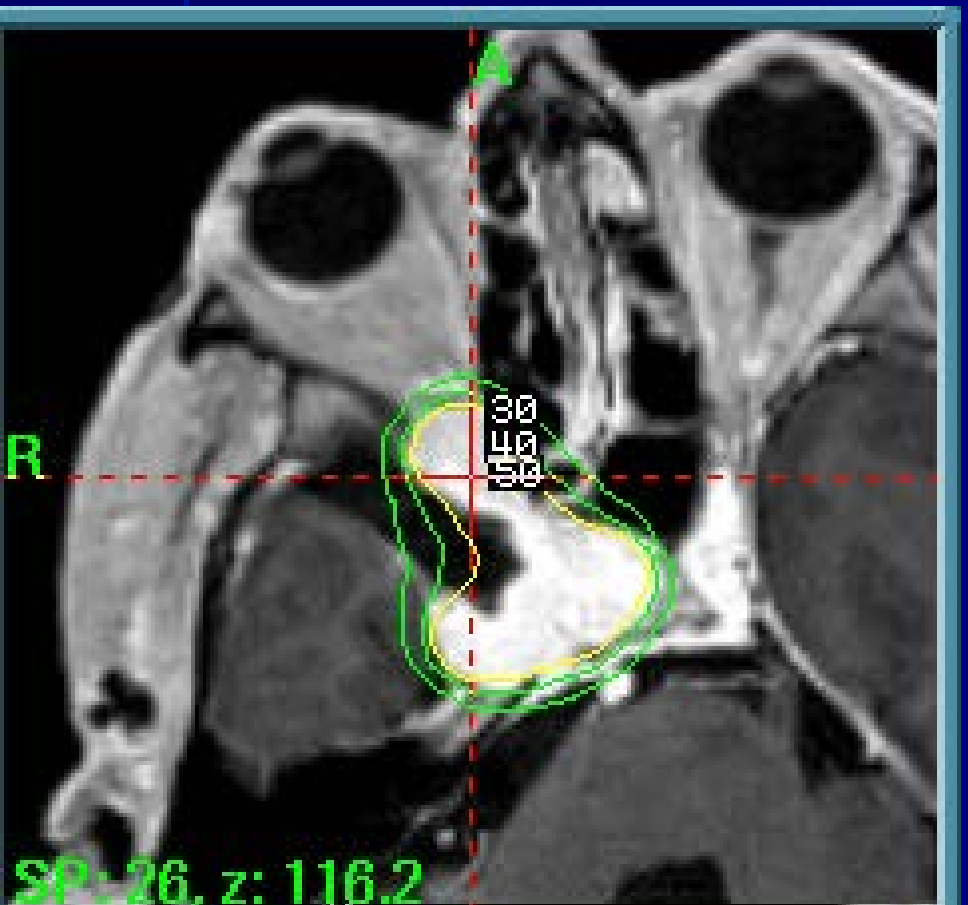
5-Intracranial SRS tedavilerinde homojenite indexi önemli bir parametre midir?

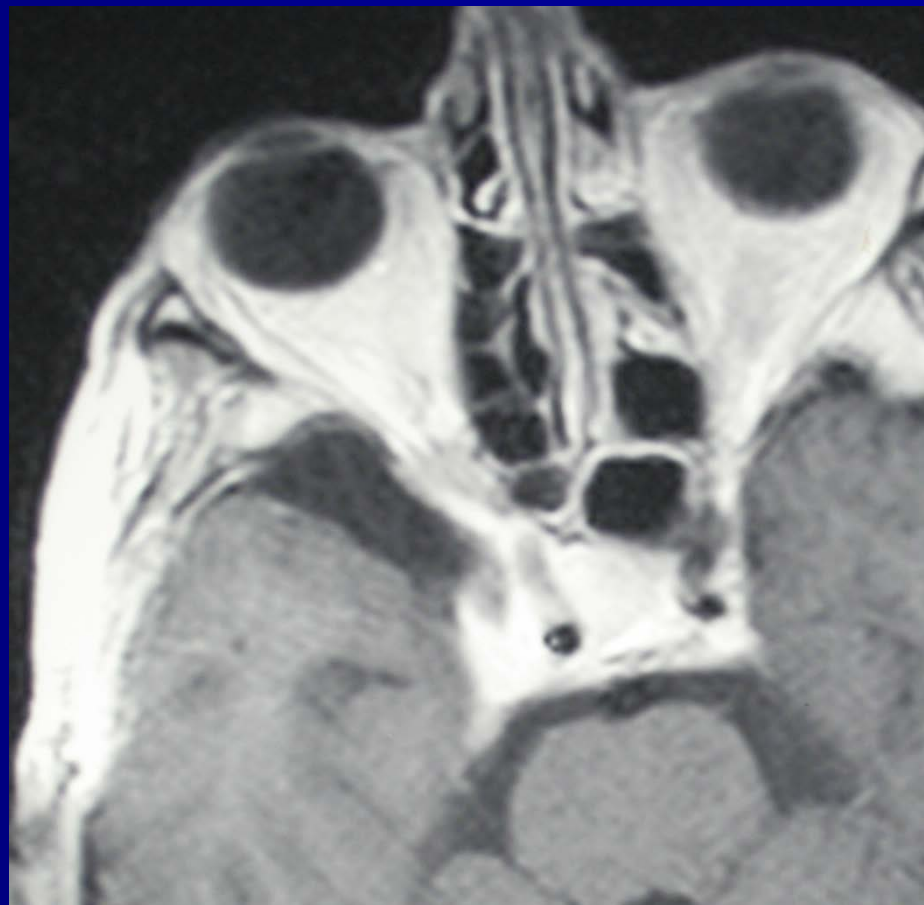
Intrakranial SRS tek fraksiyonda Uygulanır

- Hedef hacim <3,5cm
- Radyoduyarlı organlara uzaklık >3-5mm

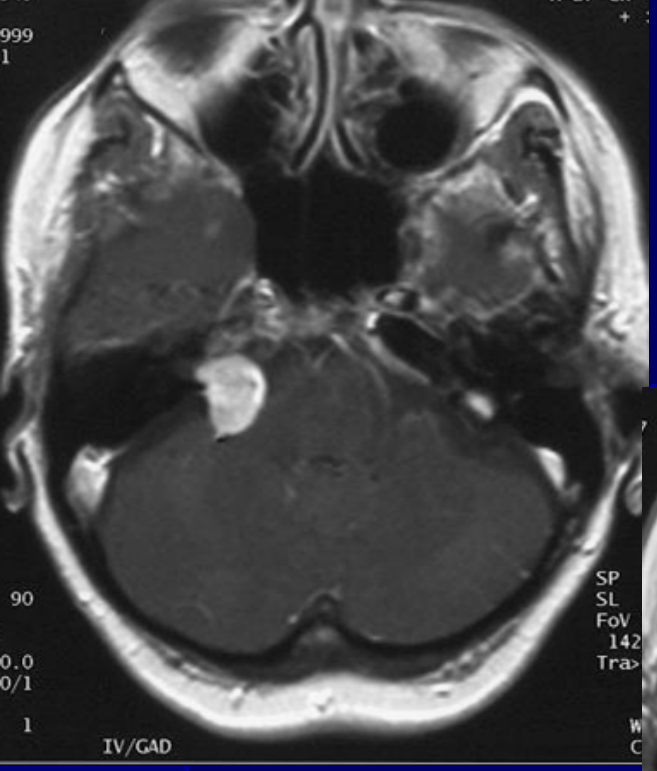
Meningioma

52/M
Cerrahi+
Post GK 8. ay

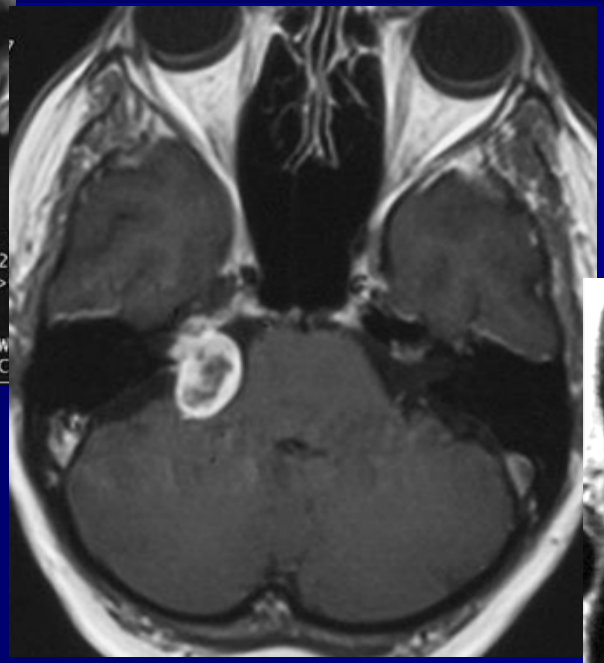




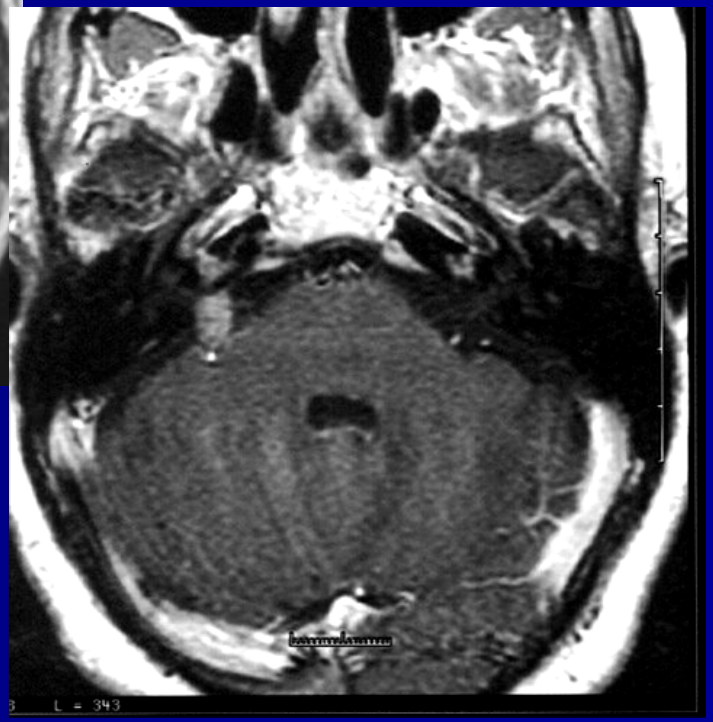
Vestibular Schwannoma-VS



öncesi



1.yıl



3.yıl

Vestibular Schwannoma MC vs GK RC

Regis et al J Neurosurg 2002

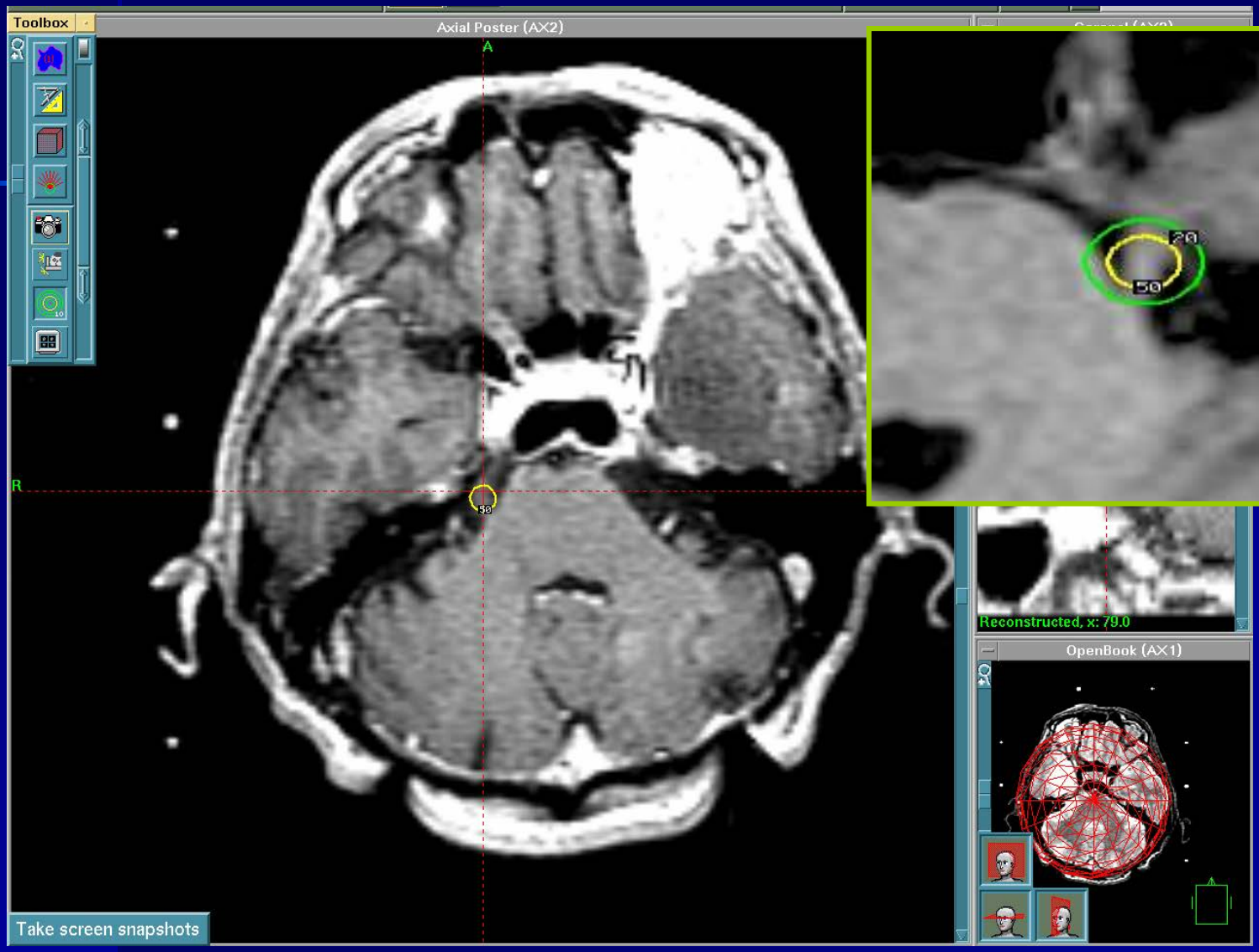
GKRC 97 olgu (ortalama izlem 4 yıl),

Microcerrahi 110 olgu

Tm boyutları aynı

Komplikasyon	MC	GKRC
Yüz siniri	47	0
Duyma Kaybı	62.5	30
Yüzde estetik kaybı	29	4
Göz problemi	83	27
Çalışma hayatına dönüş	34	1

Trigeminal Nevralji

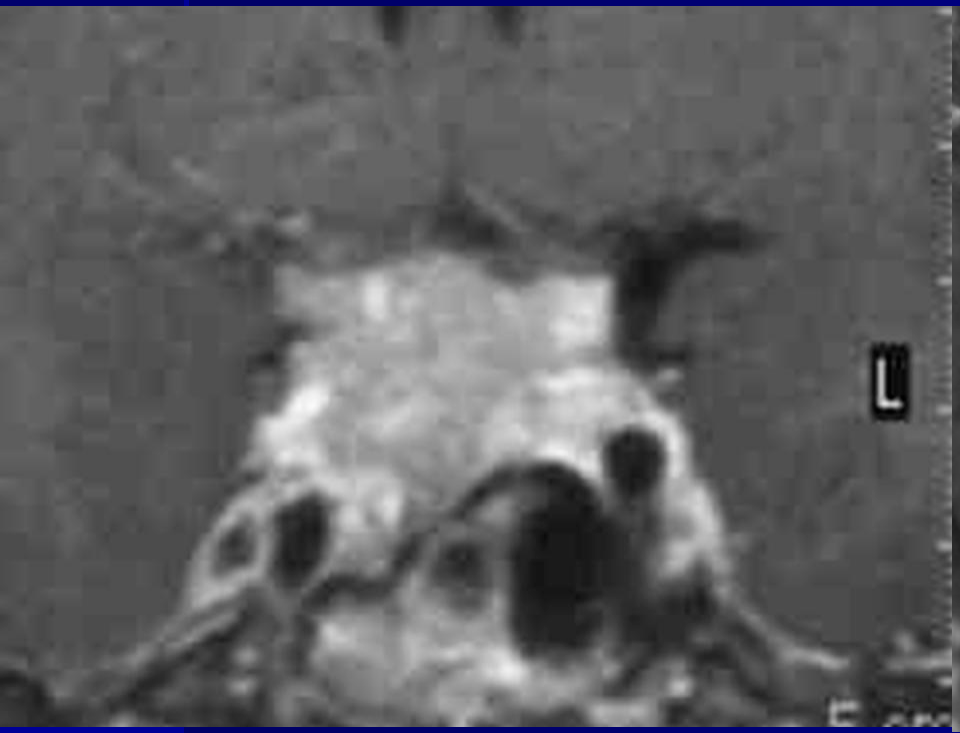


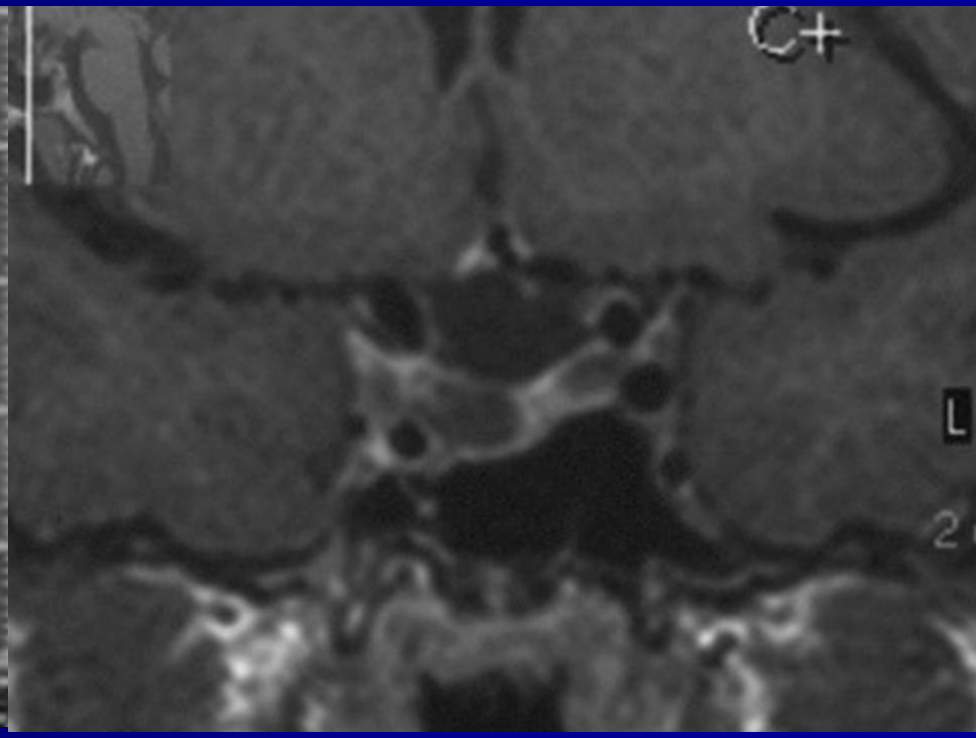
Sarı %50 izodoz
Yeşil%20 izodoz

4mm kolimatör ile tek isocenter a 70-90Gy(%100 isodoz)

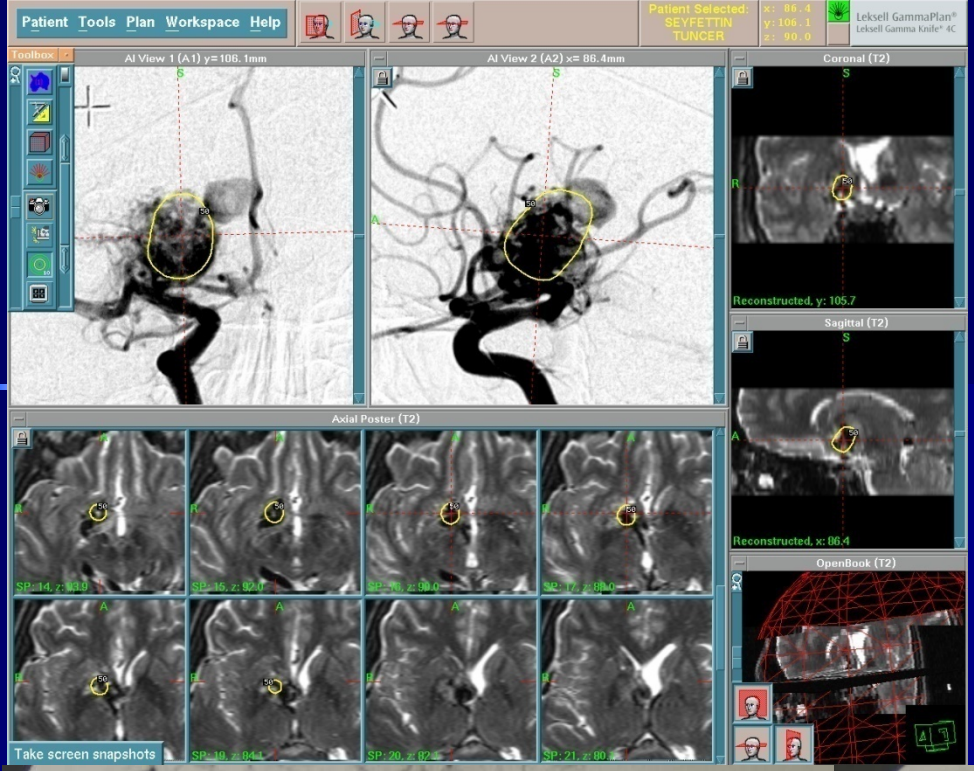
Hipofiz adenomu

26/F
Post GK 3. yıl

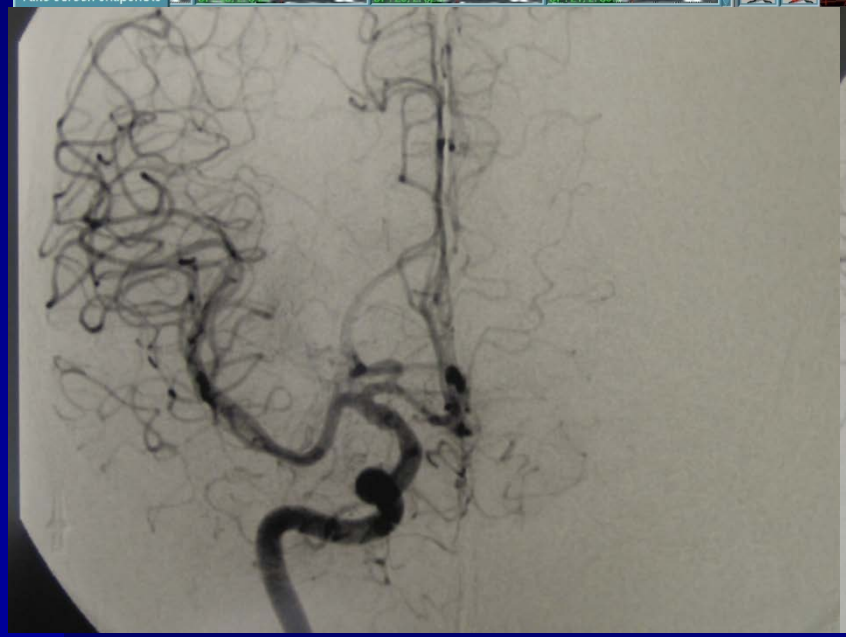


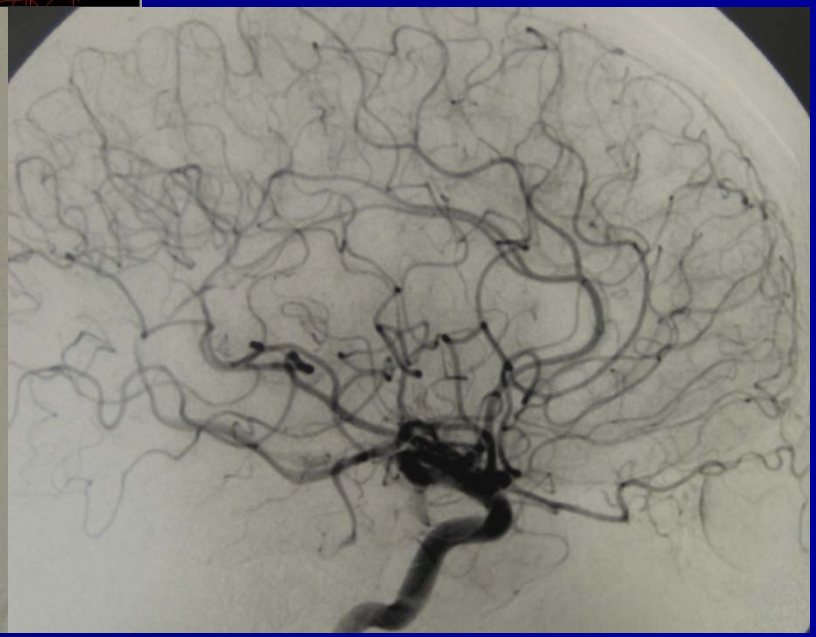


Arteriovenöz Malformasyon- **AVM**



36/M
ICH
Post GK 1. yıl





Neurosurg Focus 14 (5):Article 5, 2003, Click here to return to Table of Contents

Radiosurgery and stereotactic radiotherapy for intracranial meningiomas

RODRIGO COUTO TORRES, M.D., LEONARDO FRIGHETTO, M.D.,
ANTONIO A. F. DE SALLES, M.D., PH.D., BRIAN GOSS, M.D., PAUL MEDIN, PH.D.,
TIMOTHY SOLBERG, PH.D., JUDITH MARIANNE FORD, M.D., PH.D.,
AND MICHAEL SELCH, M.D.

Division of Neurosurgery and Department of Radiation Oncology, University of California at Los Angeles, California

77hasta SRS
51 hasta FSRT

Tm kontrol oranları
SRS (40ay)%90,
FSRT (24ay) %97
Geç komplikasyon oranları
SRS de %5,
FSRT de %5,2

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Marseille, France

Henry Dufour, M.D.

Evaluation of Fractionated Radiotherapy and Gamma Knife Radiosurgery in Cavernous Sinus Meningiomas: Treatment Strategy

OBJECTIVE: To investigate the respective role of fractionated radiotherapy (FR) and gamma knife stereotactic (GKS) radiosurgery in cavernous sinus meningioma (CSM) treatment.

METHODS: The authors report the long-term follow-up of two populations of patients harboring CSMs treated either by FR (Group I, 38 patients) or GKS radiosurgery (Group II, 36 patients). There were 31 females with a mean age of 53 years in Group I and 29 females with a mean age of 51.2 years in Group II. In 20 patients (Group I) and 13 patients (Group II), FR and GKS radiosurgery were performed as an adjuvant treatment. In 18 patients (Group I) and in 23 patients

36 SRS - 38 FSRT
Tm kontrol oranları aynı
Hastalıksız sağ kalım FSRT % 94.7 ,
SRS %94.4
Kalıcı morbidite FSRT %2,6
SRS % 0

ORIGINAL ARTICLE

Single Dose versus Fractionated Stereotactic Radiotherapy for Meningiomas

Simon S. Lo, Kwan H. Cho, Walter A. Hall, Ronald J. Kossow, Wilson L. Hernandez, Kim K. McCollow, Bruce J. Gerbi, Patrick D. Higgins, Chung K. Lee, Kathryn E. Dusenbery

ABSTRACT: ***Objective:*** To evaluate the safety and efficacy of stereotactic radiosurgery (SRS) compared to fractionated stereotactic radiation therapy (FSRT) for meningiomas treated over a seven year period. ***Methods and materials:*** Of the 53 patients (15 male and 38 female) with 63 meningiomas, 35 were treated with SRS and the 18 patients with tumors adjacent to critical structures or with large tumors were treated with FSRT. The median doses for the SRS and the FSRT groups were 1400 cGy (500- 4500 cGy) and 5400 cGy (4000-6000 cGy) respectively. Median target volumes for SRS and FSRT were 6.8 ml and 8.8 ml respectively. The median follow-up for the SRS and FSRT groups were 38 months (4.1-97 months) and 30.5 months (6.0-63 months) respectively. ***Results:*** The five-year

35 hasta SRS
18hasta FSRT
3 yıllık lokal kontrol oranı her iki grup %94
Kalıcı hasar %2,6 SRS ve
%0 FSRT olarak saptanmış.

SRS: Tm boyutu <3cm den küçük
Radyoduyarlı yapıdan >3-5mm uzak
FSRT: >3cm den büyük
Radyoduyarlı yapıdan <3-5mm olan
düzensiz şekilli

1-SRS tedavilerinde Gamma knife üstün sabitleme sistemine sahiptir.

2-Linac tabanlı SRS cihazlarında mekanik doğruluğun GK ile karşılaştırılması

3-Intracranial SRS uygulamaları tek fraksiyone tedavilerdir.

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5-Intracranial SRS tedavilerinde homojenite indexi önemli bir parametre midir?

See the corresponding editorial in this issue, pp 1578–1579.

J Neurosurg 114:1580–1584, 2011

Apparatus dependence of normal brain tissue dose in stereotactic radiosurgery for multiple brain metastases

Technical note

Lijun Ma, Ph.D.,[1] Paula Petti, Ph.D.,[2] Brian Wang, Ph.D.,[3] Martina Descovich, Ph.D.,[1] Cynthia Chuang, Ph.D.,[1] Igor J. Barani, M.D.,[1] Sandeep Kunwar, M.D.,[2] Dennis C. Shrieve, M.D., Ph.D.,[3] Arjun Sahgal, M.D.,[4] and David A. Larson, M.D., Ph.D.[1,2]

[1]Department of Radiation Oncology, University of California, San Francisco; [2]Washington Fremont Hospital Gamma Knife Center, Fremont, California; [3]Department of Radiation Oncology, University of Utah, Salt Lake City, U *re, Princess Margaret Hospi*

Discussion

This is the first report to demonstrate large apparatus-dependent differences in dose to normal brain with multiple target radiosurgery. We find that the volumes of normal brain enclosed by peripheral isodose volumes can be several times lower for Gamma Knife Perfexion versus CyberKnife and Novalis.

Multıple beyin metastazında Radyocerrahi için kullanılan cihaza bağlı olarak normal beyin dokusunun aldığı dozlar arasındaki farkı gösteren ilk çalışma

GK-Perfexion, CK ve Novalis Peddick Conformite Index Karşılaştırılması

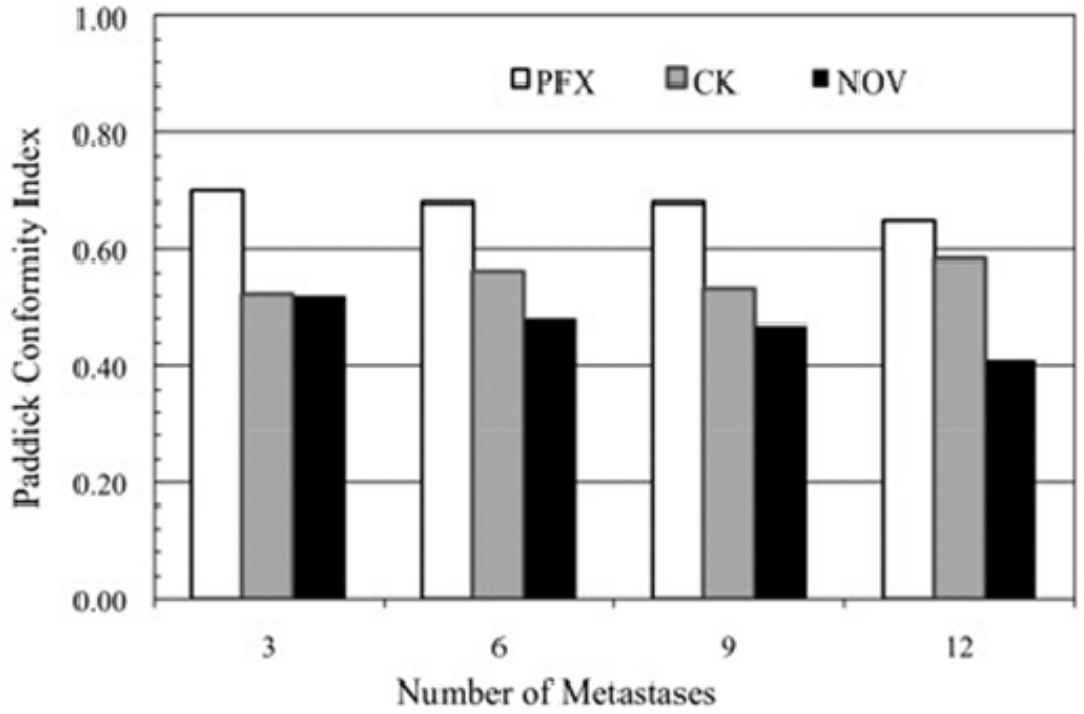

Fig. 2. Comparison of Paddick dose conformity indices for 3, 6, 9, and 12 targets. PFX = Gamma Knife Perfexion; CK = CyberKnife; NOV = Novalis.

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3-6-9-12 Metastaz Tedavi Planlarında 4- 20Gy Doza Maruz Kalan Normal Beyin Dokusu Hacimleri

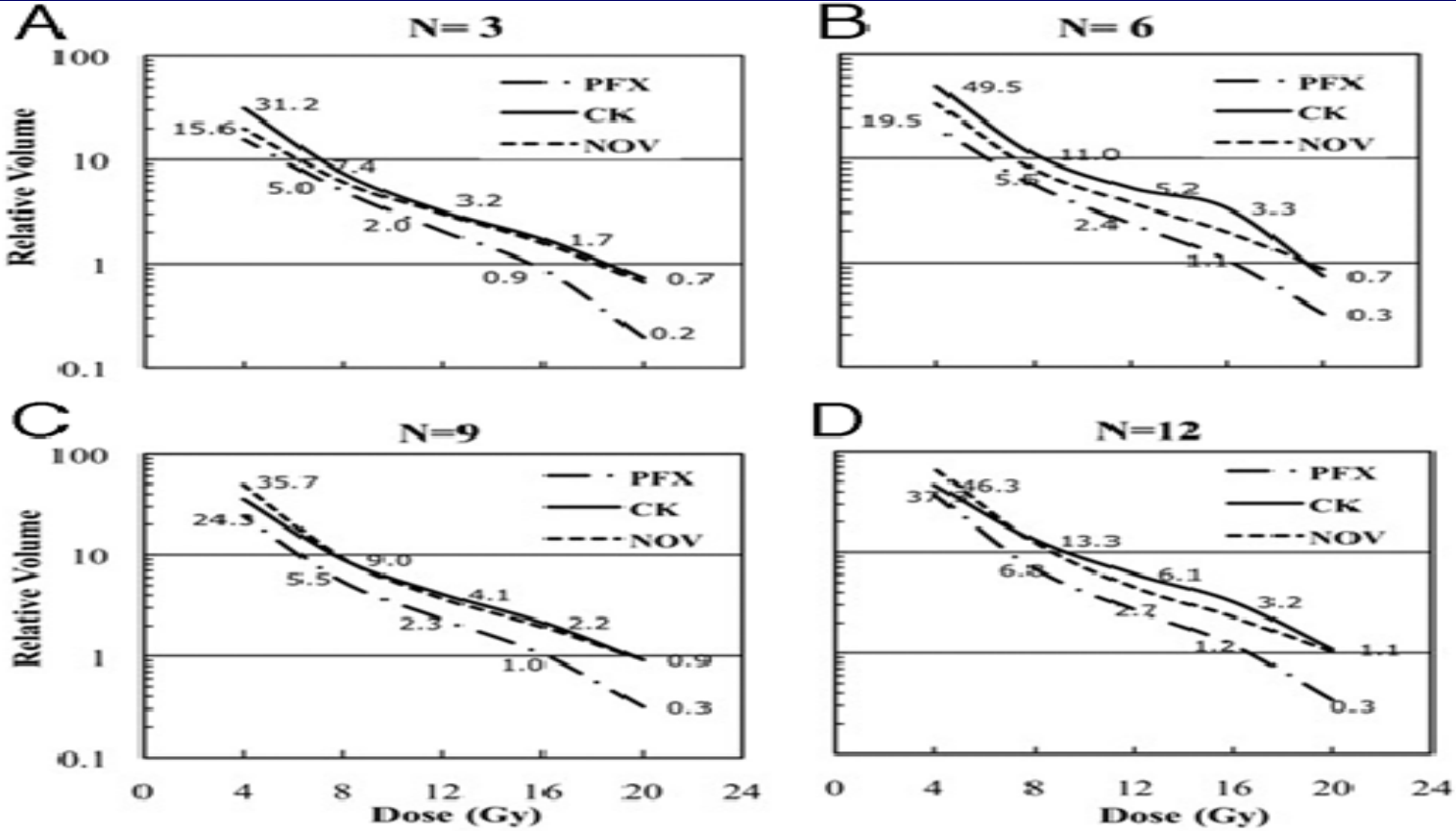
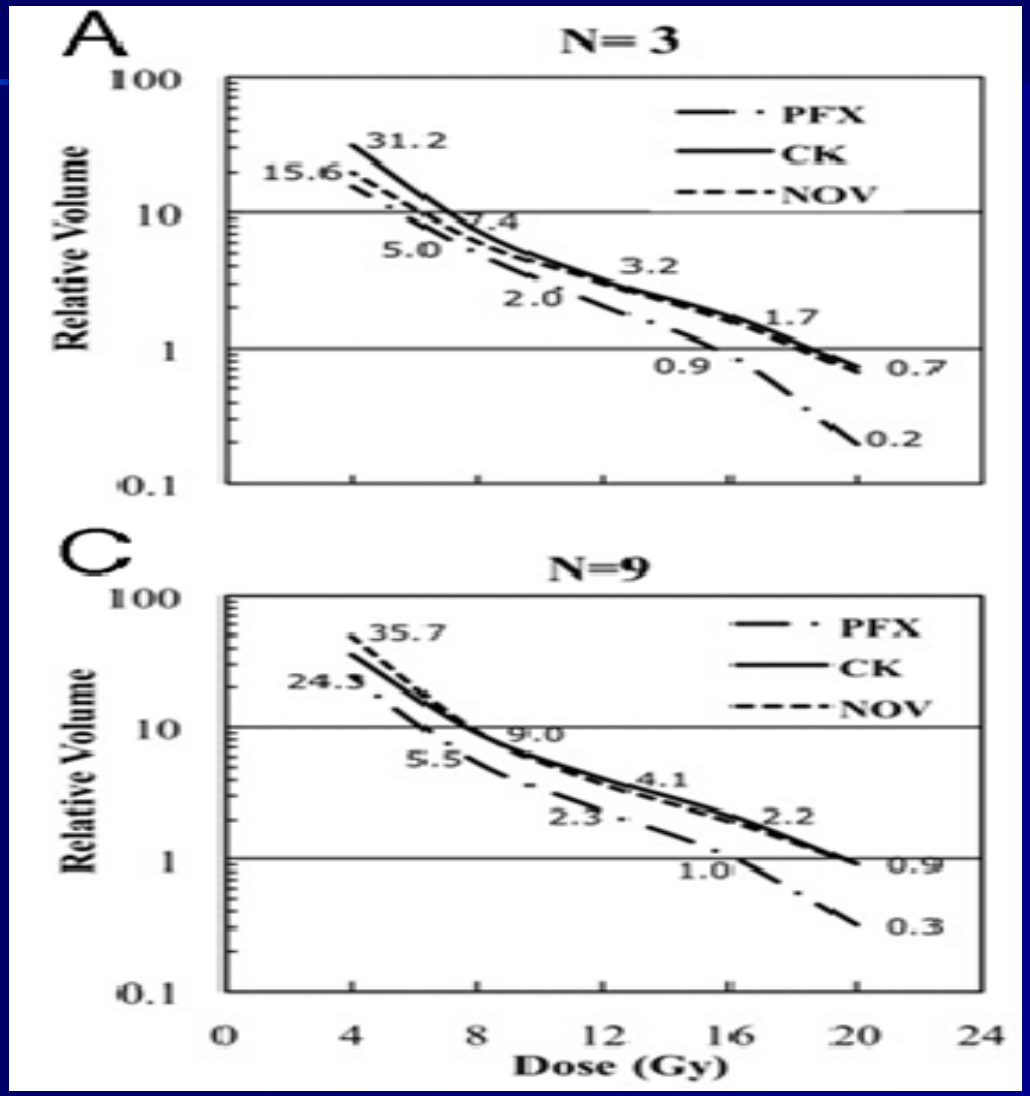


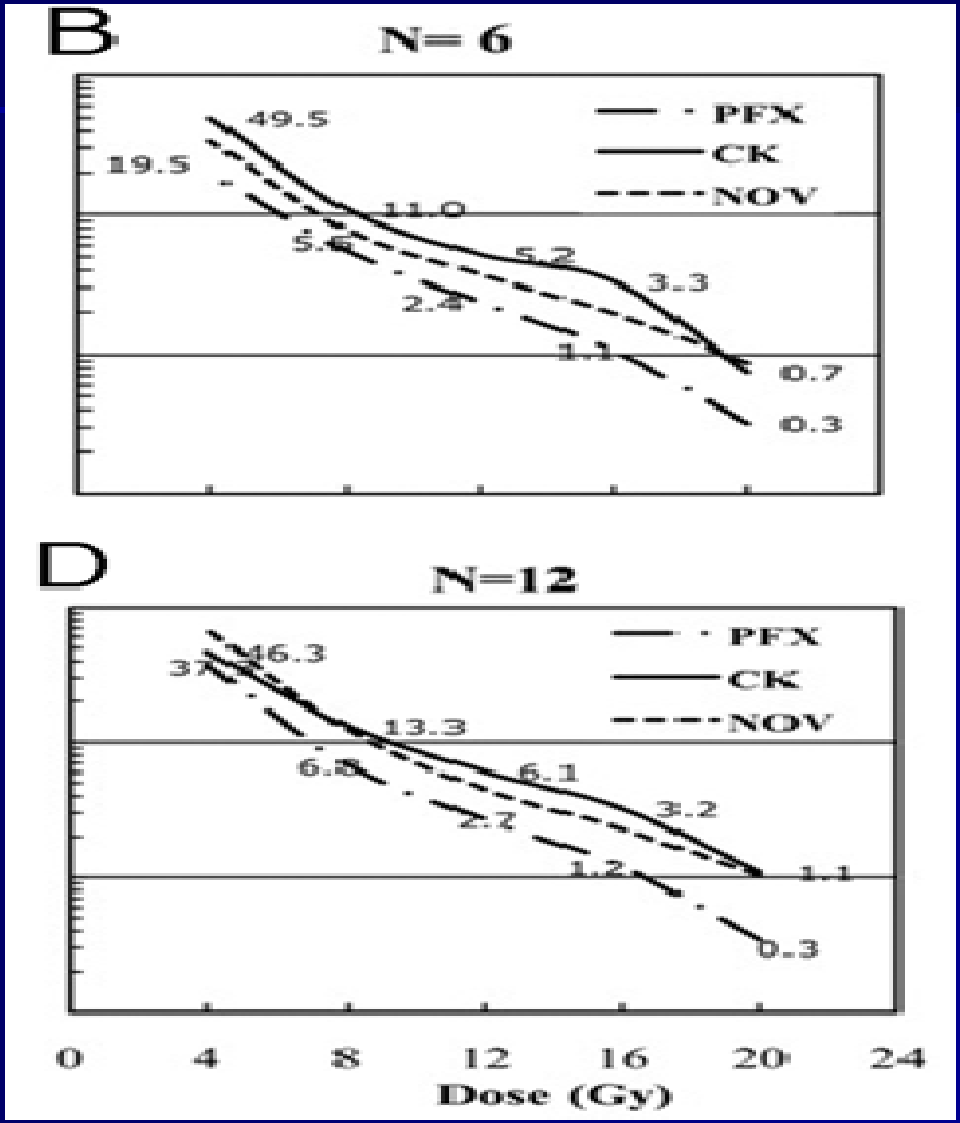
FIG. 4. Apparatus dependence of normal brain isodose volumes for multitarget treatment plans with 3 **(A)**, 6 **(B)**, 9 **(C)**, and 12 **(D)** targets. The numbers on the curves are the normalized total target volumes for Perfexion and CyberKnife for 4, 8, 12, 16, and 20 Gy, respectively.

Normal Beyin Dokusu Dozu 3ve 9 Metastaz için CK , Novalis, GK-Perfexion Cihazlarındaki Değişimi

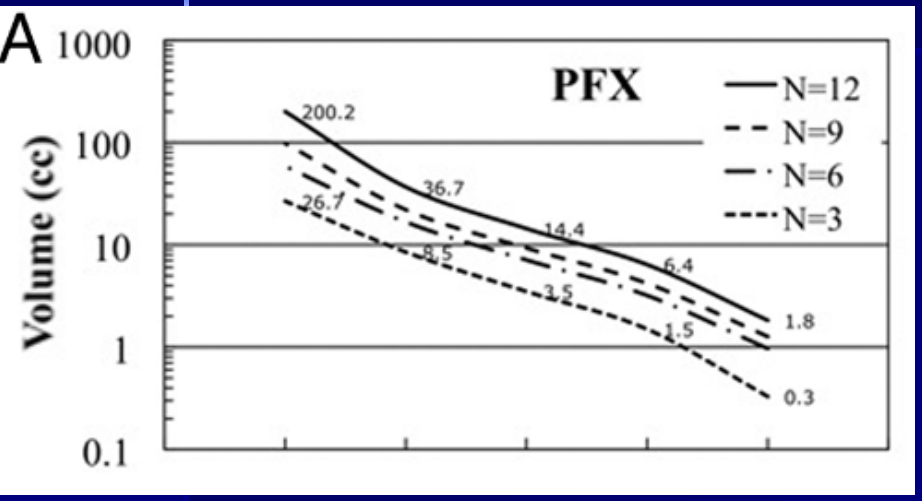
CK ve Novalis'te Benzer, GK-Perfexion'da Düşük

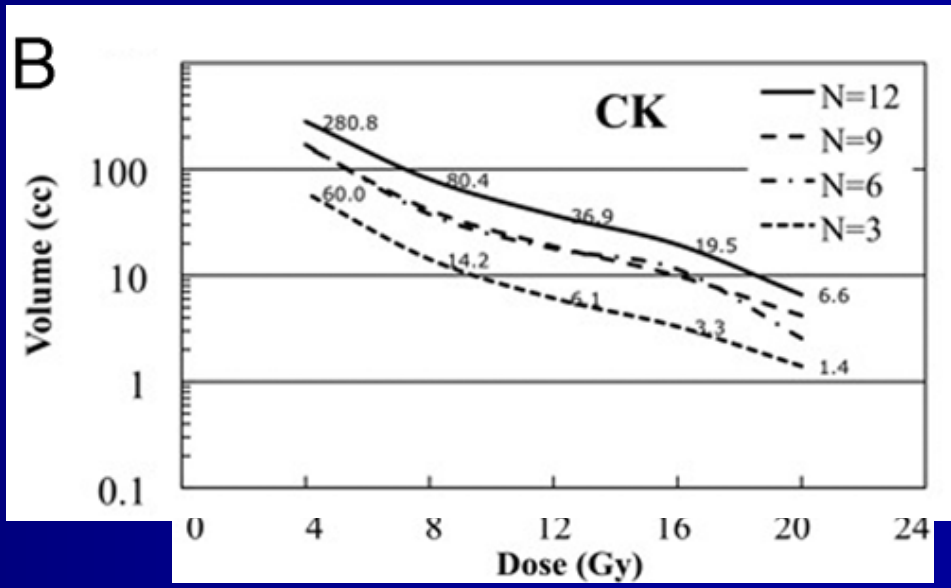


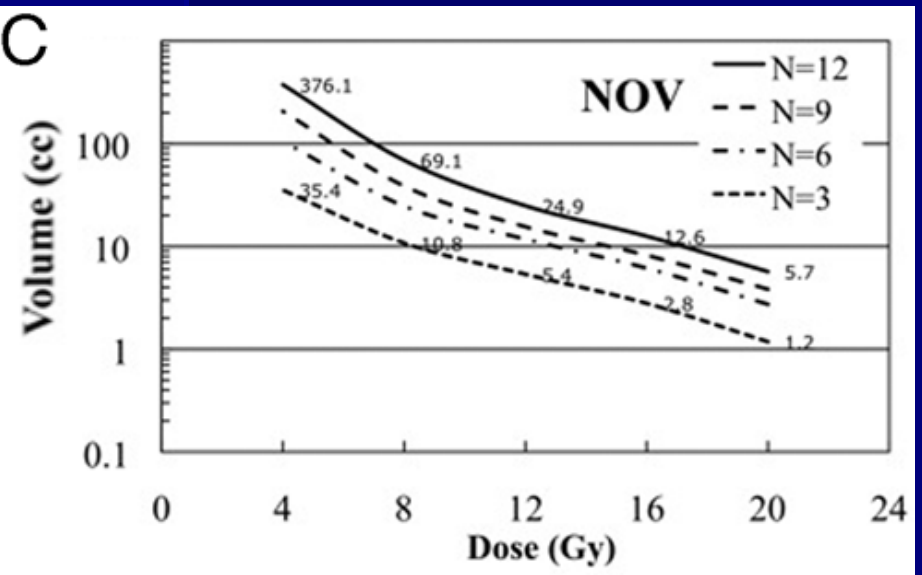
Normal Beyin Dokusu Dozunun 6ve 12 Metastaz için CK , Novalis, GK-Perfexion Cihazlarındaki Değişimi



Metastaz Sayısına Göre Normal Beyin Dokusunun Doz-Hacim Değişimi







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A dosimetric comparison between Gamma Knife and CyberKnife treatment plans for trigeminal neuralgia

Clinical article

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Conclusions. CyberKnife radiosurgical parameters can be optimized to mimic the dose distribution of Gamma Knife plans. However, Gamma Knife plans result in superior sparing of critical structures (brainstem, temporal lobe, and cranial nerves VII and VIII) and in steeper dose falloff away from the target. The clinical significance of these effects is unknown. *(DOI: 10.3171/2010.8.GKS101002)*

- GK planlarında daha keskin doz düşüşü,
- Kritik organların korunmasında daha üstün

Beyin Sapı Dozları
GK vs CK iso&non-iso

0,01cc BS hacminin aldığı dozlar

8Gy alan BS hacmi

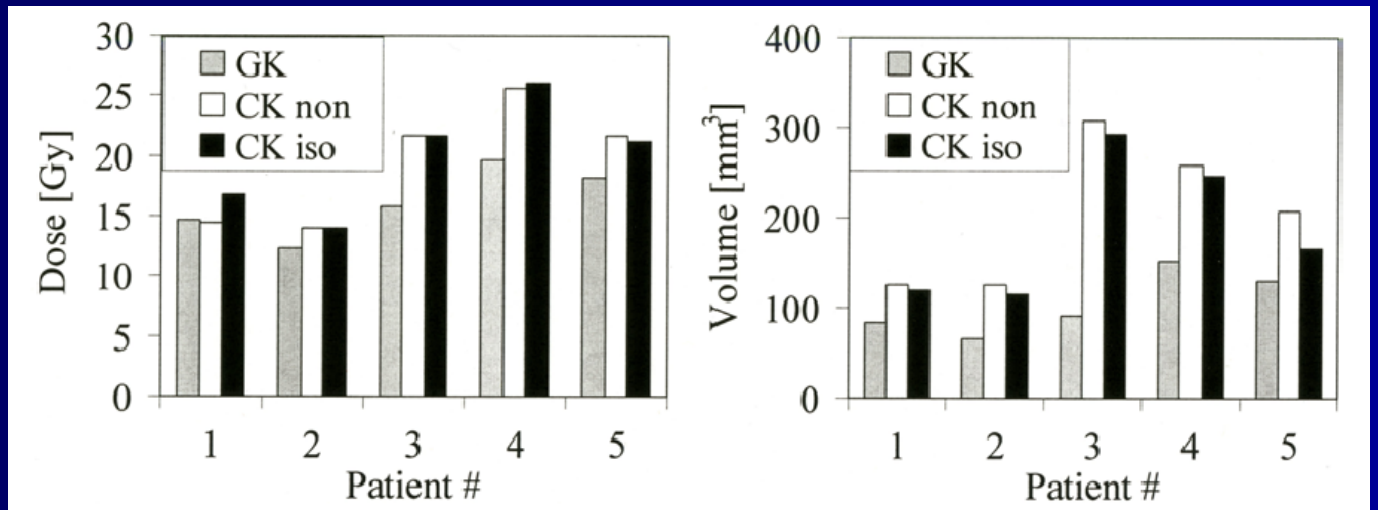

FIG. 5. Dose to 0.01 cm^3 of brainstem **(left)** and the volume of the brainstem receiving a dose of 8 Gy **(right)** in the 5 cases.

Conclusions. CyberKnife radiosurgical parameters can be optimized to mimic the dose distribution of Gamma Knife plans. However, Gamma Knife plans result in superior sparing of critical structures (brainstem, temporal lobe, and cranial nerves VII and VIII) and in steeper dose falloff away from the target. The clinical significance of these effects is unknown. *(DOI: 10.3171/2010.8.GKS101002)*

VII.ve VIII. Cranial Sinirin 1mm³Hacim Dozları
GK vs CK iso&non-iso

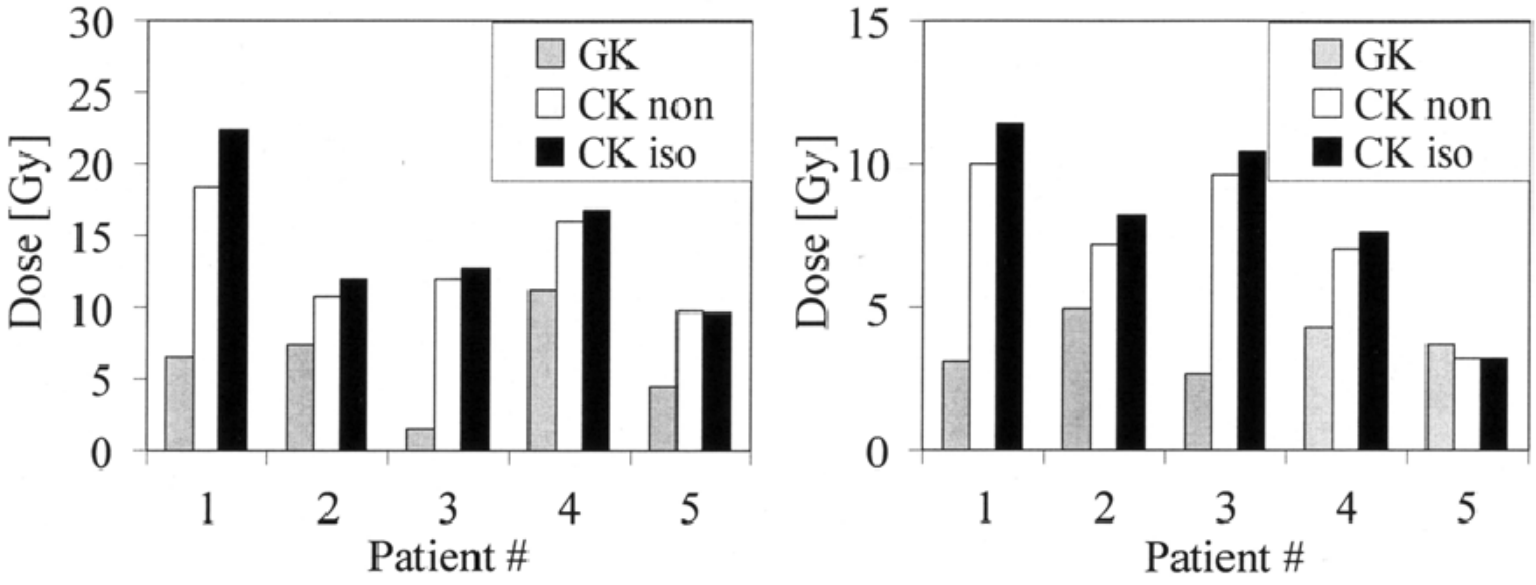

FIG. 7. Dose to 1 mm³ of CNs VII **(left)** and VIII **(right)** in the 5 cases.

1-SRS tedavilerinde Gamma knife üstün sabitleme sistemine sahiptir.

2-Linac tabanlı SRS cihazlarında mekanik doğruluğun GK ile karşılaştırılması

3-Intracranial SRS uygulamaları tek fraksiyone tedavilerdir.

4-Çoklu metastazların tedavisinde SRS tedavileri için üç cihazdan hangisi en iyi çözüm olabilir?

5-Intracranial SRS tedavilerinde homojenite indexi önemli bir parametre midir?

Heterojen Doz Dağılımı

- GK da %50 prescription isodose
- Küçük hacimli hedefin içinde yüksek doz √
- Hedefin komşuluğunda hızlı doz düşüşü√
- TCP ⬆
- NTCP ⬇

Stereotactic body radiation therapy: The report of AAPM Task Group 101

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IV.D.1. Dose heterogeneity, gradient and fall-off, and beam geometry

organs at risk. This practice increases dose heterogeneity within the target.[27,109] However, in contrast to conventionally fractionated radiotherapy, dose heterogeneities within the target for SBRT are acceptable for targets not involving functional normal tissue. Hot spots within the target volumes are generally viewed to be clinically desirable, as long as there is no spillage into normal tissue. It has been hypothesized that hotspots within the central region of a tumor might offer a special advantage in eradicating radioresistant hypoxic cells that might be more likely located there.[120] While the locations of hypoxic subregions in solid tumors might not be stable,[121] regardless, the observed dose response for tumor

Gamma Knife (Perfexion)	CyberKnife & LINAC tabanlı SRS
Rijid sabitleme sistemi kullanılarak kafa hareketi önlenir. Stereotaktik çerçeve kafa kemiğine fixe edilir. Yüksek tedavi doğruluğu	Rijit olmayan sabitleme sistemi kafa hareketini azaltır, tedavi sırasındaki hareketini önleyemez. Maske ile fixasyon Daha az pozisyon doğruluğu
Mekanik doğruluk 0.2mm.	0.5-1 mm doğruluk
Tek seansta yapılan uygulamalara ait sonuçlar başarılı	fraksiyone tedavi de amaç etkinliğin arttırılması yada yan etkilerin azaltılması olmalı (gerekiyorsa!)
Çoklu metastazda normal doku dozu düşük	Normal doku dozu daha yüksek
Heterojen doz dağılımının ve hızlı doz düşüşünün olumlu etkisi	Hedefin dışında doz düşüşü daha az

Gamma Knife Altın Standart

- Intracranial hastalıkların SRS ile tedavisi ve klinik etkinliği 4 dekattan fazla zamandır yapılmakta ve sonuçları bildirilmektedir.
- 3000 den fazla yayın, 600000 üstünde hasta tedavisi

Teşekkürler…