Planeación de Neuralgia del Trigémino y Talamotomia

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ALAIR

Radiocirugía Funcional

- Algunas características especiales
  - Dosis MUY altas (Ej. Neuralgia de Trigémino 90Gy, Talamotomia 140Gy, etc..)
  - Fracción única
  - Incidencias NO coplanares
  - Blanco ULTRA pequeños algunos < 5mm
  - Tiempos de tratamiento largos muchos > 1 hora
  - Pocas indicaciones
  - Características especiales de pacientes
  - Información de núcleos basales + OARs
  - Fibras nerviosas
  - Planificación de tratamiento

Requiere verificación y/o corrección de posición

Dosimetría CRITICA - PENUMBRA

Confort del paciente - Anestesia

Dolor, temblor, TOC, etc..

Sistemas automáticos delimitación OARs y Núcleos

Software especifico vinculados el TPS

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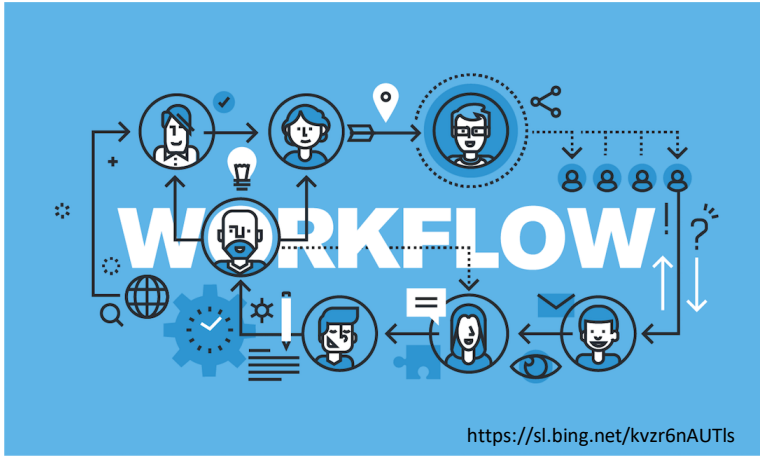
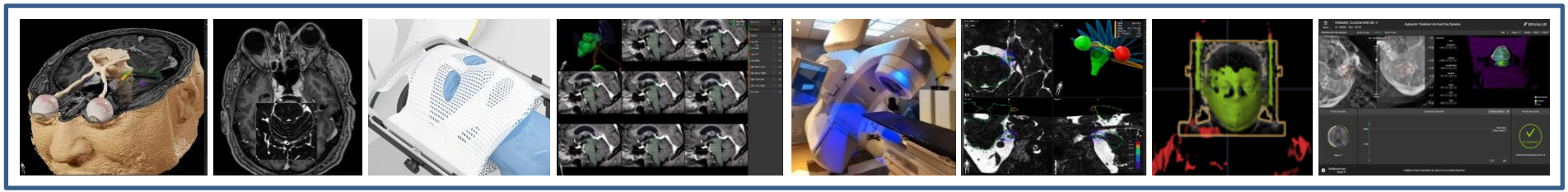
SRS Funcional cerebral con LINAC

- Que se requiere ?
  - **Visualización** de imágenes de alta resolución
  - **Fusión** de imágenes rígida y deformable
  - Delimitación de OARs/Núcleos basales - **Auto segmentación**
  - Visualización de **coordenadas indirectas**
  - **Tractografía**
  - Sistema de **Inmovilización** – Posicionamiento FrameLess
  - Acelerador Lineal con **precisión estereotáxica**
  - **Sistema de colimación y planificación (TPS) dedicado**
  - Tratamiento guiado por imágenes, **IGRT** todo ángulo de mesa

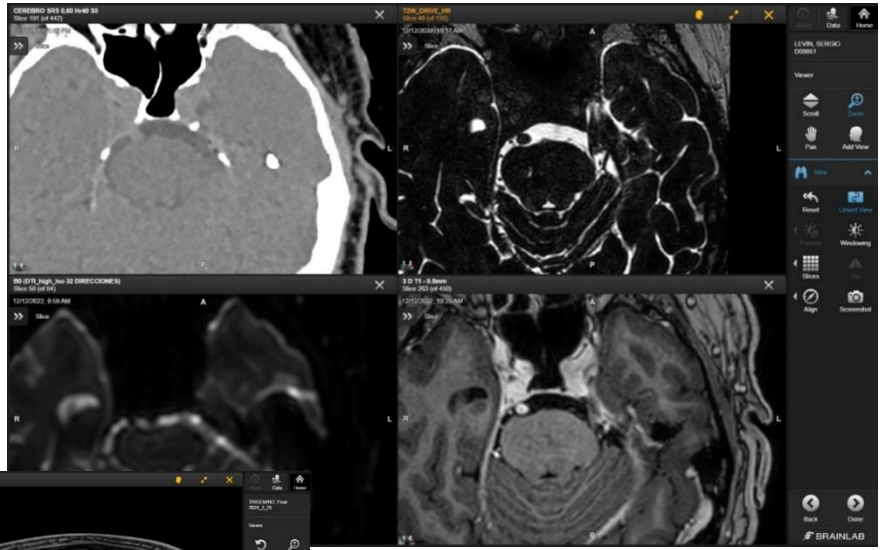


https://sl.bing.net/kvzr6nAUTls



Imágenes Visualización

- Múltiples Modalidades
  - CT / MRI / DTI / CCA, etc.…
- TAC sintética
- Resolución
- Distorsión
- Realidad aumentada
- CBCT (HyperSight)
- Utilidad realidad virtual ? …



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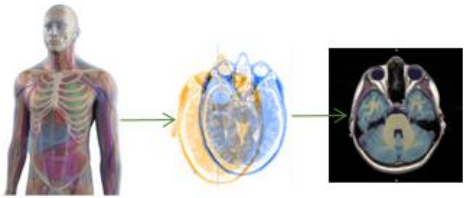
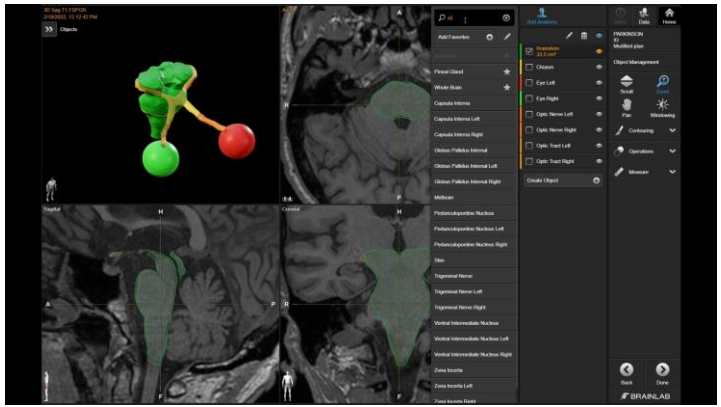
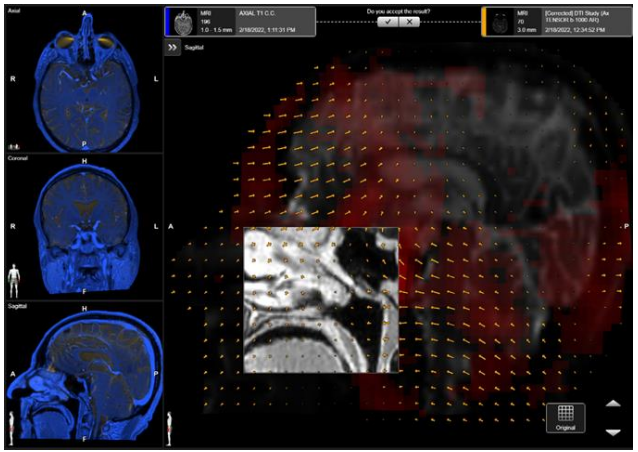
Auto segmentación - Tractografía

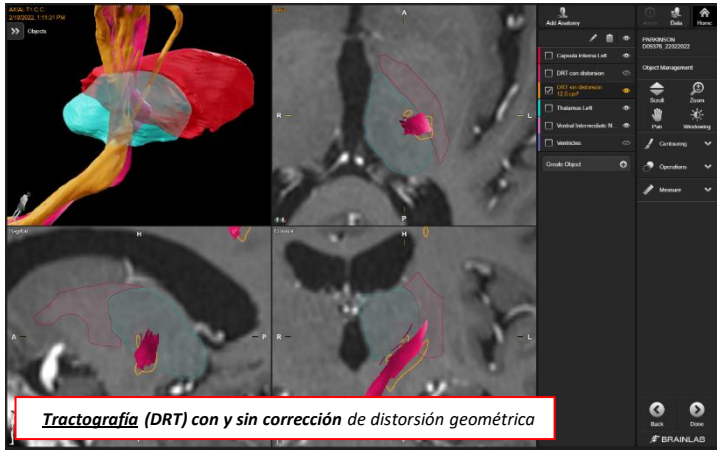
- Auto segmentación
  - Órganos a riesgo (OARs)
  - Núcleos basales





- Tractografía
  - Imágenes DTI (DSI)
  - Anisotropía de difusión
  - Distorsión





Tractografía ***(DRT) con y sin corrección*** *de distorsión geométrica*

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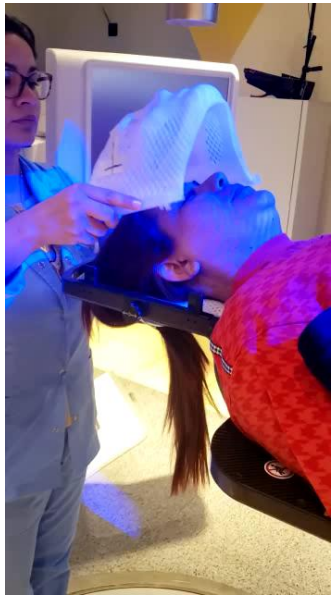
SRS Funcional LINAC – **Inmovilización FrameLess**

- **Mascaras termoplásticas**
- Soporte 4Pi
  - Reduce riesgo de colisión
  - Mejora la calidad de imagen
- Mascara abierta - Anestesia
- Confort del paciente
  - Tiempo de tratamiento ~ 1 hora



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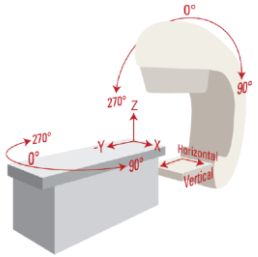
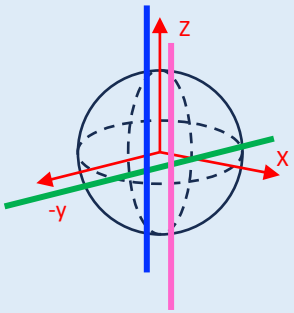
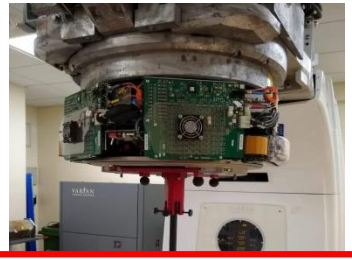
SRS Funcional LINAC – **Precisión Mecánica**



Real





2.C.2.2.2 | *Tolerance.* The tolerance will vary with machine use. Non-IMRT machine laser tolerance is ±2.0 mm, IMRT machines is ±1.0 mm, and machines used for SRS/SBRT treatments is <1.0 mm deviation. Tolerances can be made more stringent at the discretion of the QMP.

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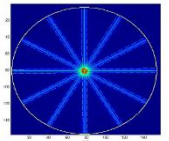
AAPM SCIENTIFIC REPORT

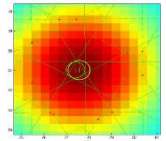
MEDICAL PHYSICS

AAPM Task Group 198 Report: An implementation guide for TG 142 quality assurance of medical accelerators

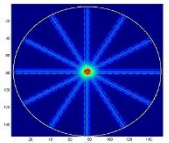
Joseph Hanley[1] | Sean Dresser[2] | William Simon[3] | Ryan Flynn[4] | Eric E. Klein[5] | Daniel Letourneau[6] | Chihray Liu[7] | Fang-Fang Yin[8] | Bijan Arjomandy[9] | Lijun Ma[10] | Francisco Aguirre[11] | Jimmy Jones[12] | John Bayouth[13] | Todd Holmes[14]

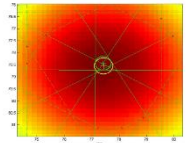
$$SD_{Total} = \sqrt{\sum SD^2_{Geometricas}}$$



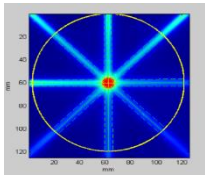


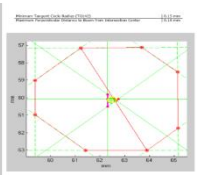
collimator





couch





gantry

Collimation system

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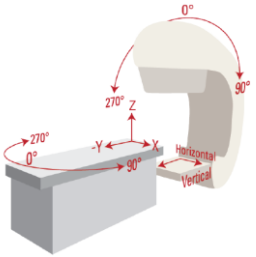
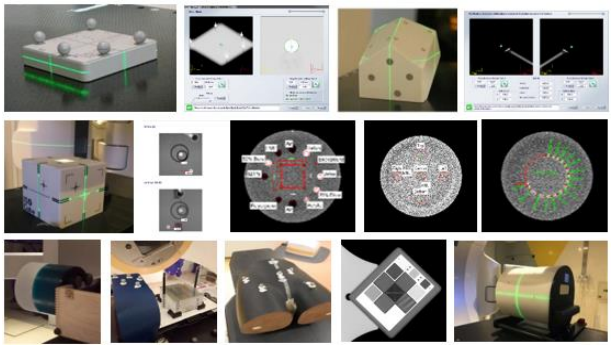
SRS Funcional LINAC – **Imágenes (IGRT)**



TG142 - TG198

Procedure	non-SRS/SBRT	SRS/SBRT
Daily[a]		
Planar kV and MV (EPID) imaging		
Collision interlocks	Functional	Functional
Positioning/repositioning	≤2 mm	≤1 mm
Imaging and treatment coordinate coincidence (single gantry angle)	≤2 mm	≤1 mm
Cone-beam CT (kV and MV)		
Collision interlocks	Functional	Functional
Imaging and treatment coordinate coincidence	≤2 mm	≤1 mm
Positioning/repositioning	≤1 mm	≤1 mm



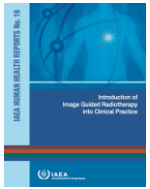


TABLE 1. LEVELS OF IGRT ACCORDING TO THE METHODOLOGY AND TOOLS ASSOCIATED WITH EACH STEP OF THE PROCEDURE

Procedure	Level 1 3-D CRT, including off-line portal imaging	Level 2 Standard IGRT: 3-D CRT/IMRT with off-line or on-line IGRT	Level 3 Advanced IGRT: 3-D CRT/IMRT with on-line advanced IGRT
Treatment delivery unit			Same as Level 2 plus motion management and 6-D corrections

of the dose delivered to the target. These are essential in the delivery of high doses per fraction in very few fractions. Therefore, in SRT treatments, the verification of target location in all treatment positions during all fractions for the entire procedure should ideally be achieved at sub-millimeter precision. This is achievable in tests with phantoms, but in patients it is more problematic, due to the uncertainties discussed below. Nevertheless, IGRT helps to keep the total positional uncertainty within a few millimeters.

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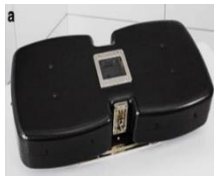
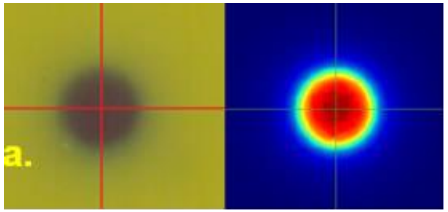
SRS Funcional LINAC – **Sistema de colimación**

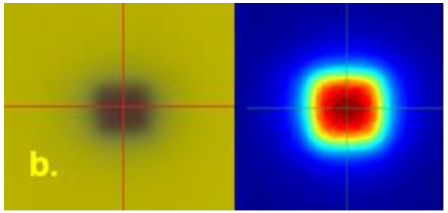
Cone
Penumbra 1.2mm

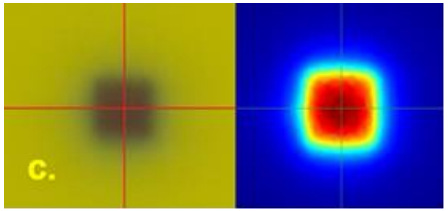
HDMLC
Penumbra 2.0mm



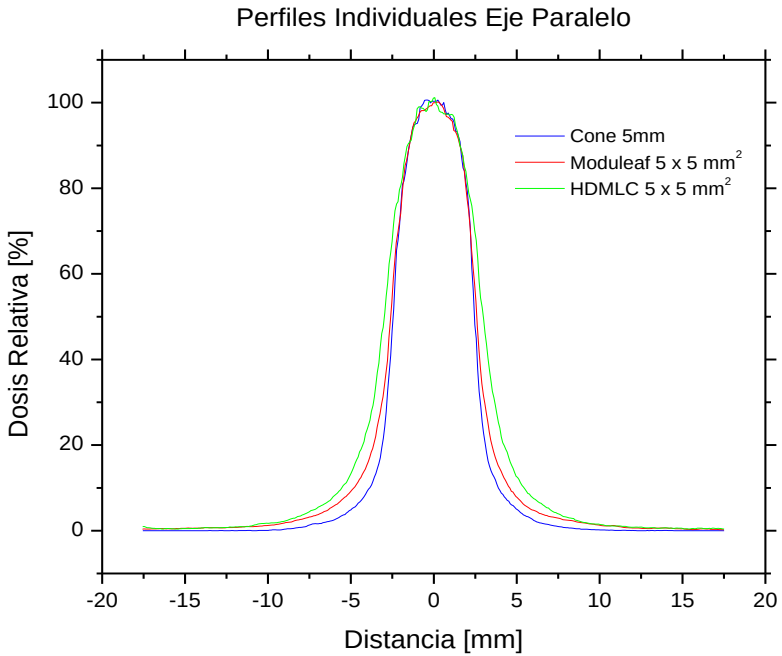
µMLC
Penumbra 1.7mm







Sistema Terciario!
Se debe verificar alineamiento



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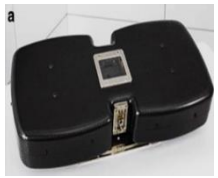
Vacca, N., et.al. (2014), SU-E-T-122: Dosimetric Comparison Between Cone, HDMLC and MicroMLC for the Treatment of Trigeminal Neuralgia. Med. Phys., 41: 250-250. https://doi.org/10.1118/1.4888452

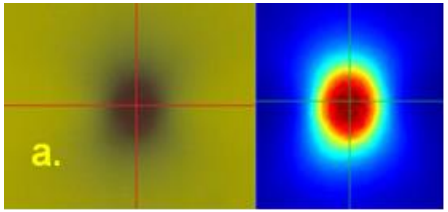
SRS Funcional LINAC – **Sistema de colimación**

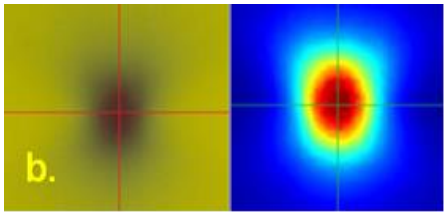
Cone
Penumbra 1.2mm

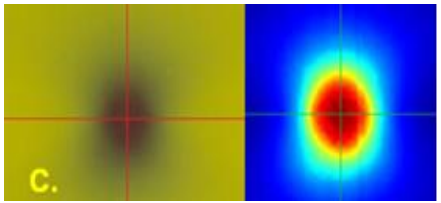
HDMLC
Penumbra 2.0mm



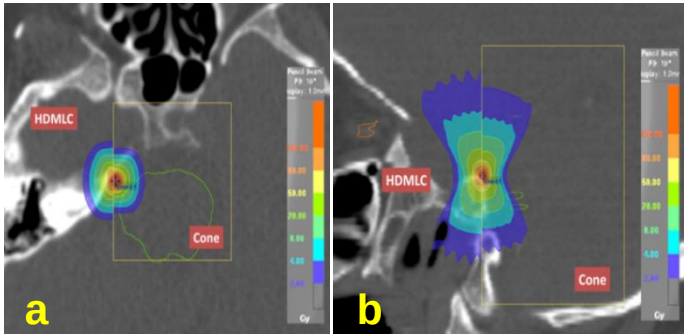
µMLC
Penumbra 1.7mm

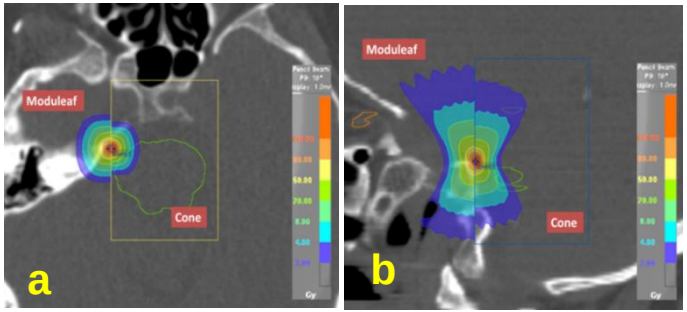






Sistema Terciario!
Se debe verificar alineamiento





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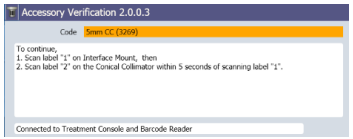
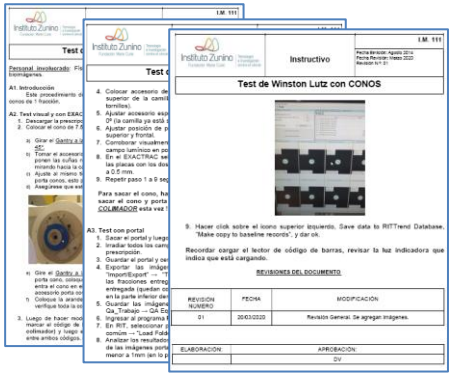
SRS Funcional LINAC – **Sistema de colimación**

Cone

HDMLC

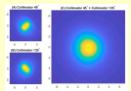
µMLC

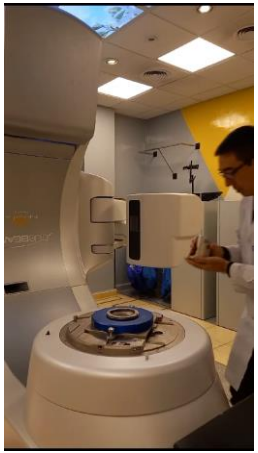




- Conos Físicos
  - Penumbra ajustada
  - Dosimetría bien establecida
  - Algoritmo de calculo simple
  - PSQA simple
  - Sistema de verificación
  - Accesorio adicional
  - Reducción del espacio al isocentro
  - Menos control de la distribución

- Conos Virtuales ?





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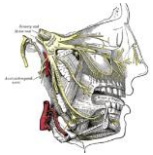
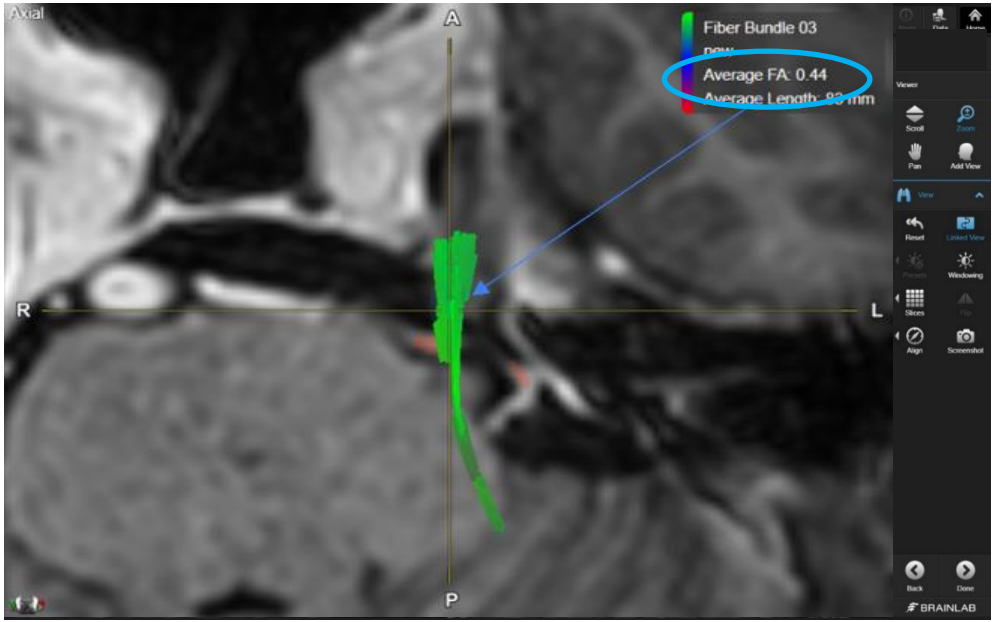
SRS Funcional LINAC - Trigémino

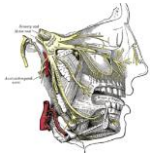


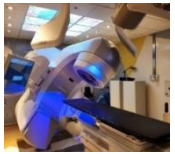
- CT simulación (0.6 mm)
  - Deflexión de la cabeza / FOV
- MRI 3Tesla (0.5 mm)
  - T2 (FIESTA – Balance)
  - MRA (Angio 3D TOF)
  - VOL T1 con y sin gadolinio

- Imágenes por Tensor de Difusión (DTI)
  - Confirmación blanco
  - Evidencian integridad de fibras
  - Detectan una disminución o alteración de FA (integridad funcional del nervio)

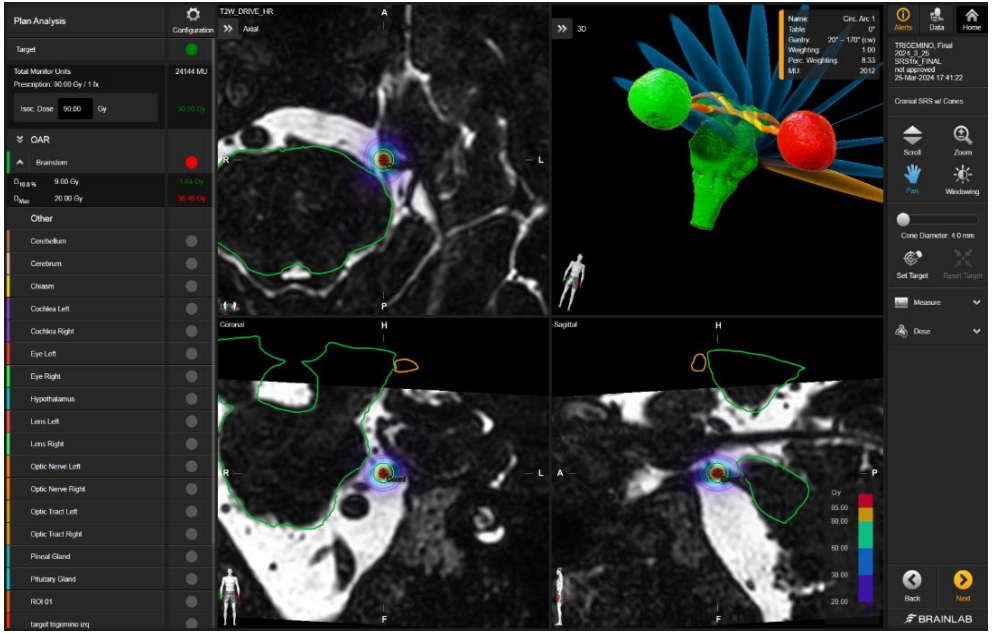


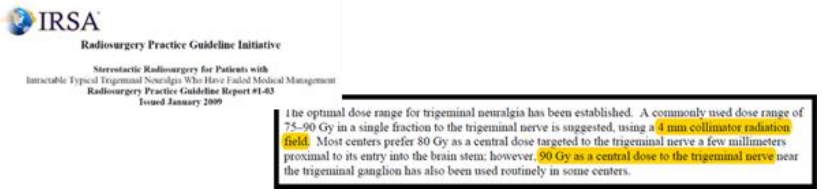
SRS Funcional LINAC - **Trigémino**





- Prescripción: **90Gy** – Dmax (isocentro)
- Arcos Cono 4mm
  - 12 arcos no coplanares de 150deg / Mismo peso
- Algoritmo calculo: Pencil Beam
- Grilla calculo: 0.5 mm
- Plantillas Geometría/Tratamiento
- Posición de isocentro
  - Tipico: segmento retrogasseriano del nervio trigémino dentro del espacio cisternal (segun criterio medico)
  - Dosis Tronco Dmax [0.035cc] < 30Gy / D0.5cc < 20Gy





IRSA

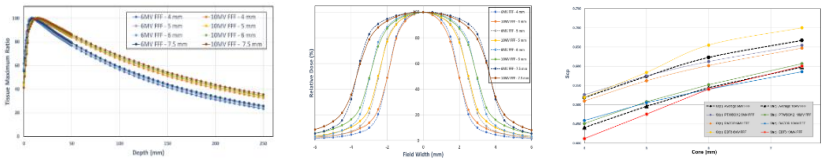
Radiosurgery Practice Guideline Initiative

Stereotactic Radiosurgery for Patients with Intractable Typical Trigeminal Neuralgia Who Have Failed Medical Management

Radiosurgery Practice Guideline Report #1-03

Issued January 2009

The optimal dose range for trigeminal neuralgia has been established. A commonly used dose range of 75–90 Gy in a single fraction to the trigeminal nerve is suggested, using a 4 mm collimator radiation field. Most centers prefer 80 Gy as a central dose targeted to the trigeminal nerve a few millimeters proximal to its entry into the brain stem; however, 90 Gy as a central dose to the trigeminal nerve near the trigeminal ganglion has also been used routinely in some centers.



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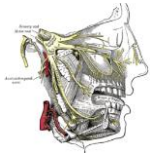
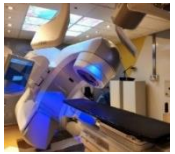
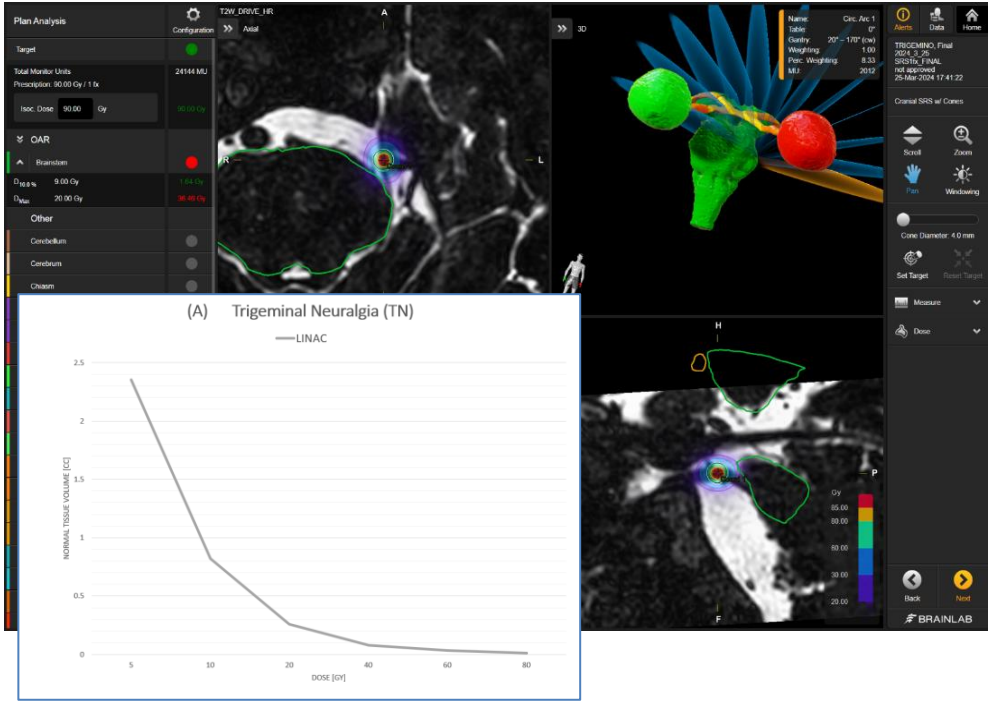
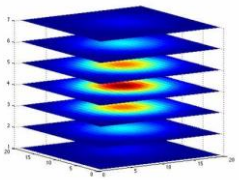
SRS Funcional LINAC - **Trigémino**





- Prescripción: 90Gy – Dmax (isocentro)
- Arcos Cono 4mm
  - 12 arcos no coplanares de 150deg / Mismo peso
- Algoritmo calculo: Pencil Beam
- Grilla calculo: 0.5 mm
- Plantillas Geometría/Tratamiento
- Posición de isocentro
- HDV – FWHM ejes principales





TN	V5Gy [cc]	2.35
	V10Gy [cc]	0.82
	V12Gy [cc]	0.61
	V18Gy [cc]	0.30
	V50% [cc]	0.069
	GI [V35%/V70%]	3.73

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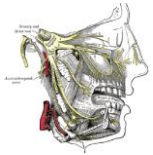
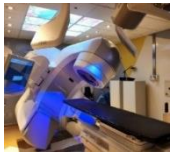
SRS Funcional LINAC - **Trigémino**





- Prescripción: 90Gy – Dmax (isocentro)
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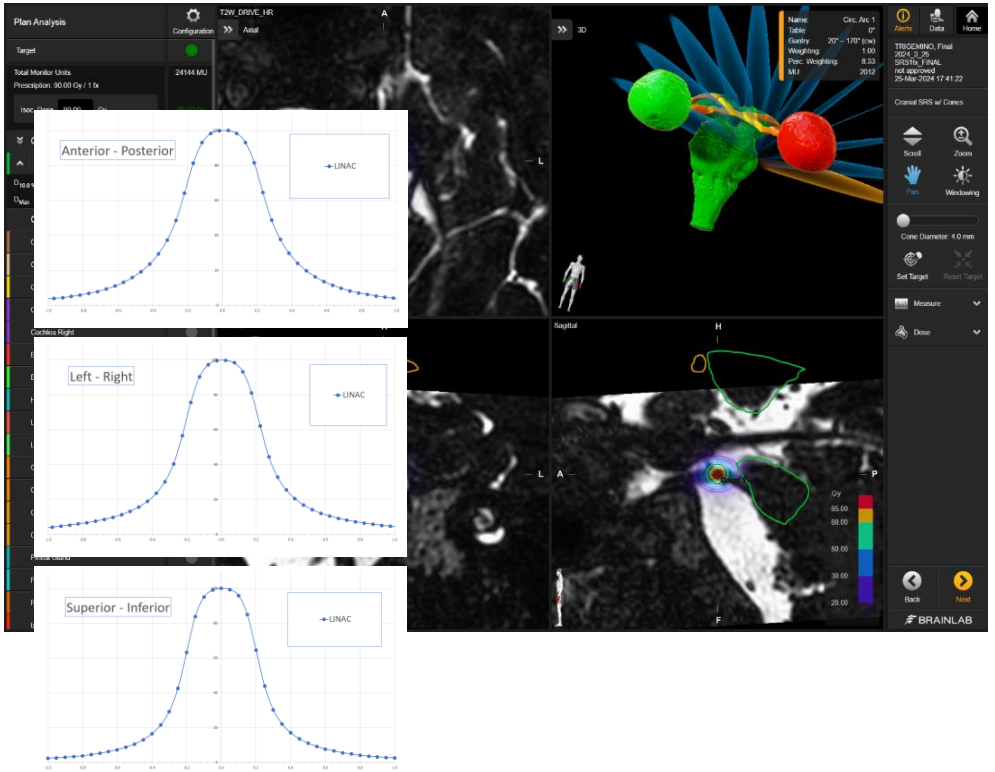

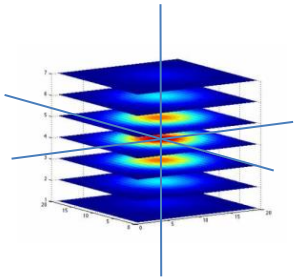

	Linac FWHM [cm]	Linac Penumbra L/R [cm]
A-P	0.505	0.3/0.3
L-R	0.541	0.3/0.3
S-I	0.469	0.25/0.25

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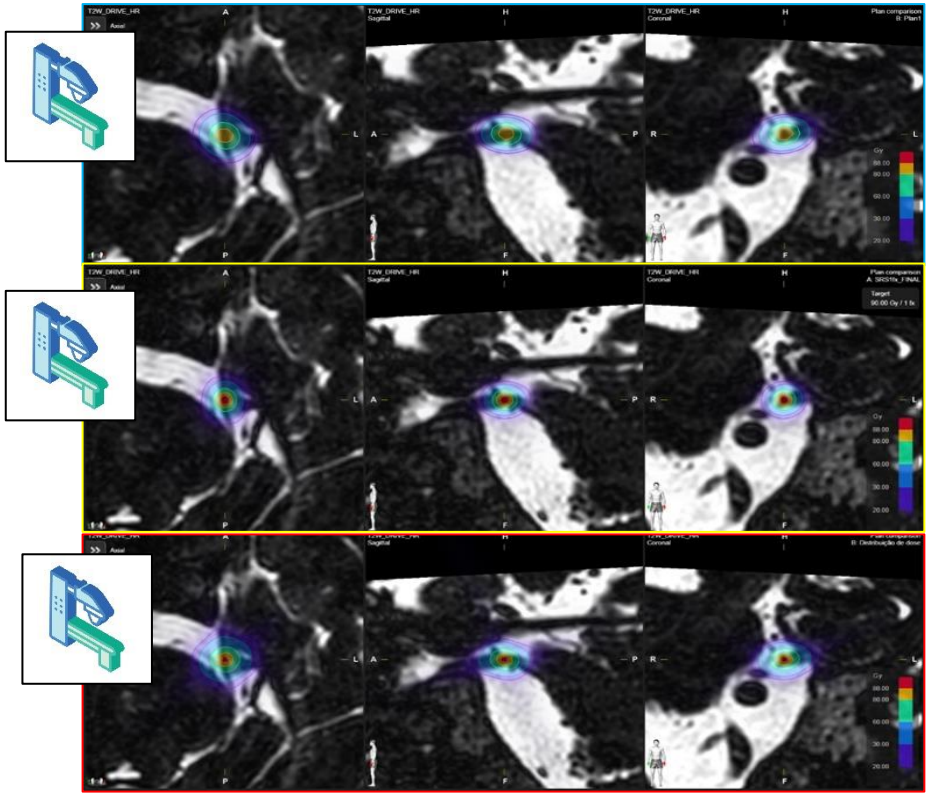
SRS Funcional LINAC - **Trigémino**



- Prescripción: 90Gy – Dmax (isocentro)
- Arcos Cono 4mm
  - 12 arcos no coplanares de 150deg / Mismo peso
- Algoritmo calculo: Pencil Beam
- Grilla calculo: 0.5 mm
- Plantillas Geometría/Tratamiento
- Posición de isocentro
- HDV – FWHM ejes principales
- Comparación GammaKnife - CyberKnife

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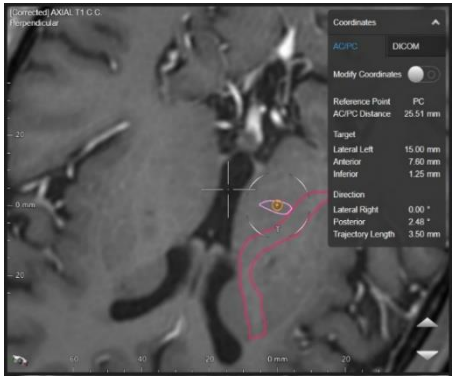
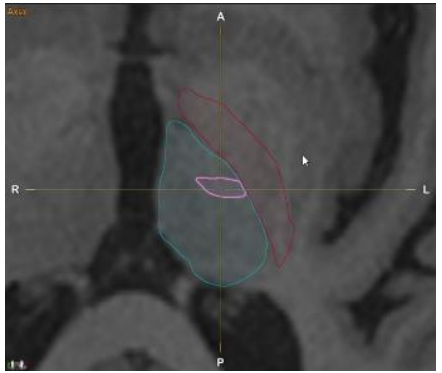
SRS Funcional LINAC - **Tremor**

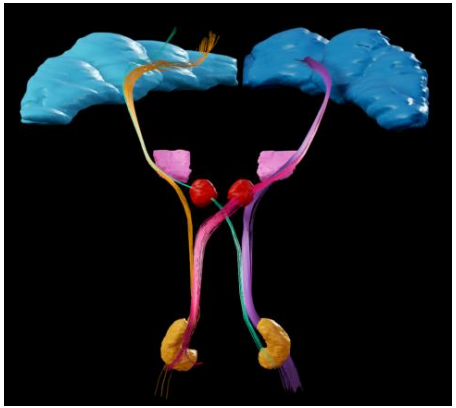
Isocentro

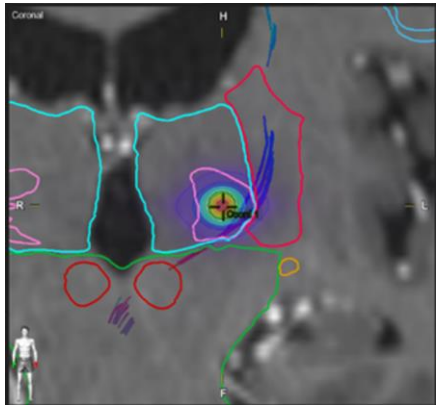
Neurocirujano y Radioncólogo tienen la responsabilidad de definir la posición del isocentro utilizando:

1. Coordenadas indirectas
2. Segmentación automática de nucleos basales
   - VIM
   - Capsula Interna
3. Tractografía
   - Imágenes DTI con corrección de distorsión
   - Fibras DRT - CST
4. Distribución de dosis
   - Capsula Interna (<30% línea de isodosis)
   - Tractografía









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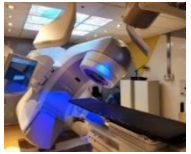
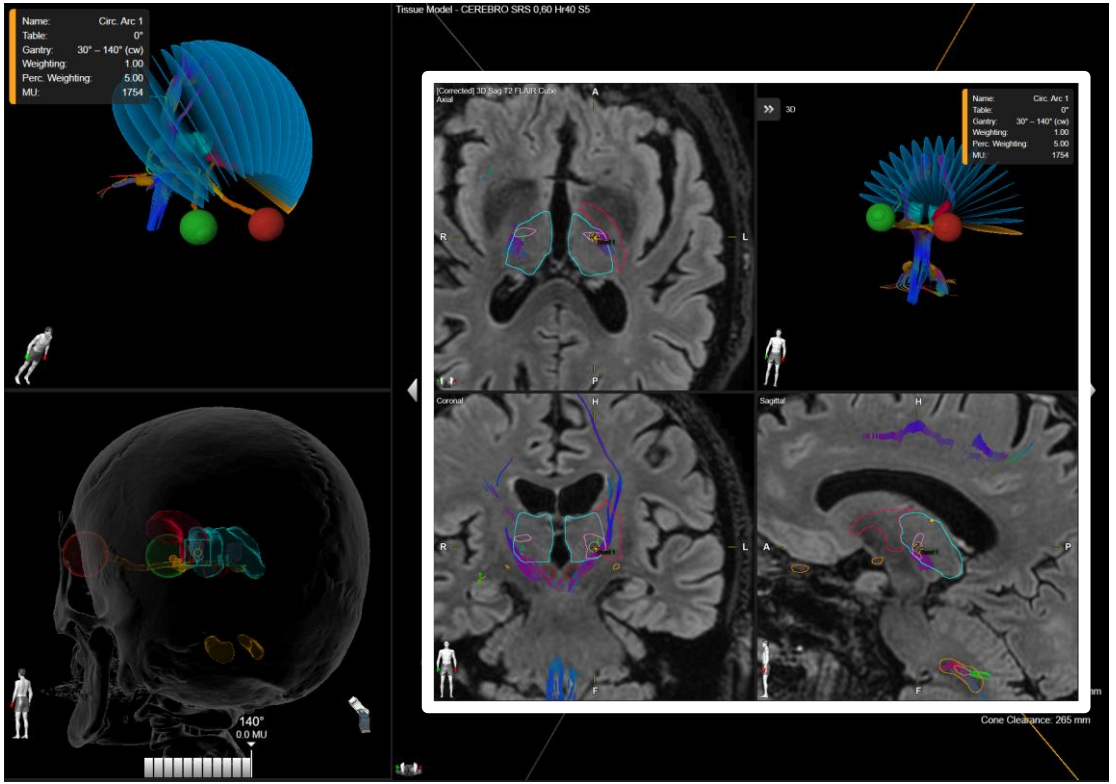


- Posición inicial Isocentro
- **Planificación**
  - Dosis prescripción: **140Gy** – Dmax
  - ARCOS 110° - Todos mismo peso
  - Algoritmo calculo: Pencil Beam
  - Grilla calculo: 0.5 mm
  - Plantillas Geometría/Tratamiento



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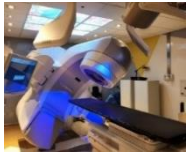
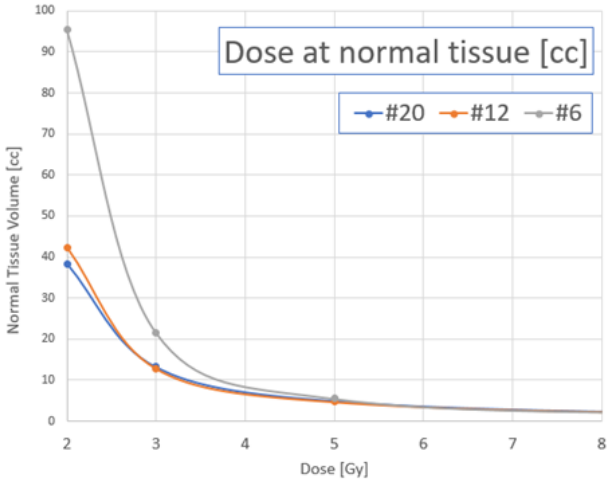
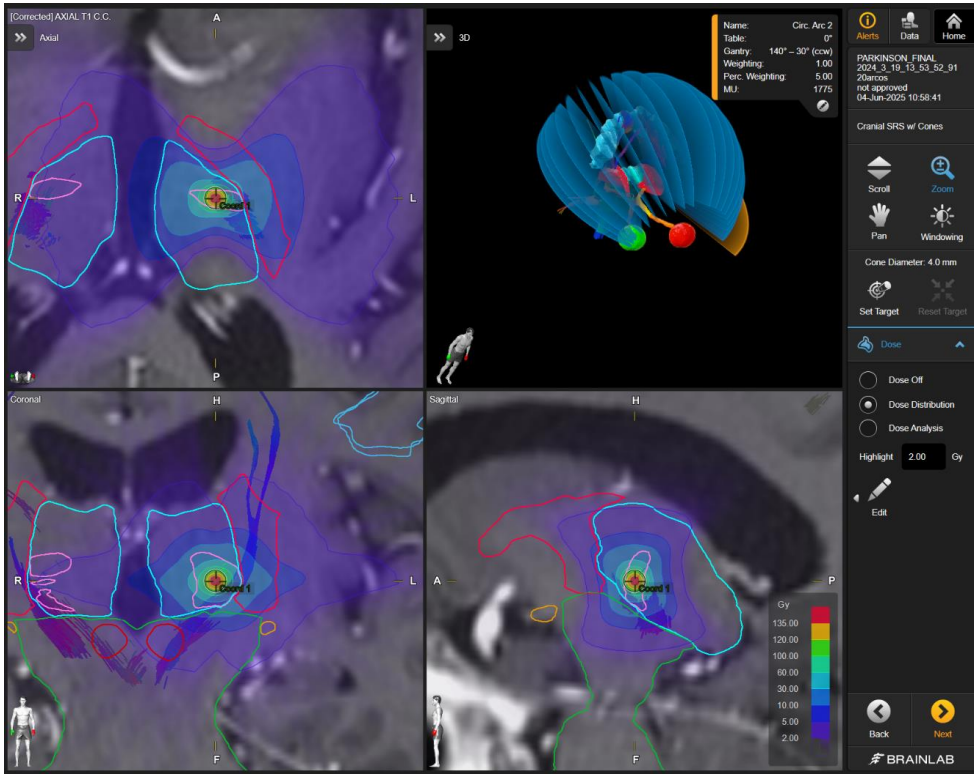
SRS Funcional LINAC - **Tremor**



- **# posiciones de mesa ?**
  - 6, 12 o 20 ?
  - Diferencia pude verse solo en dosis bajas





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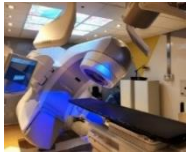
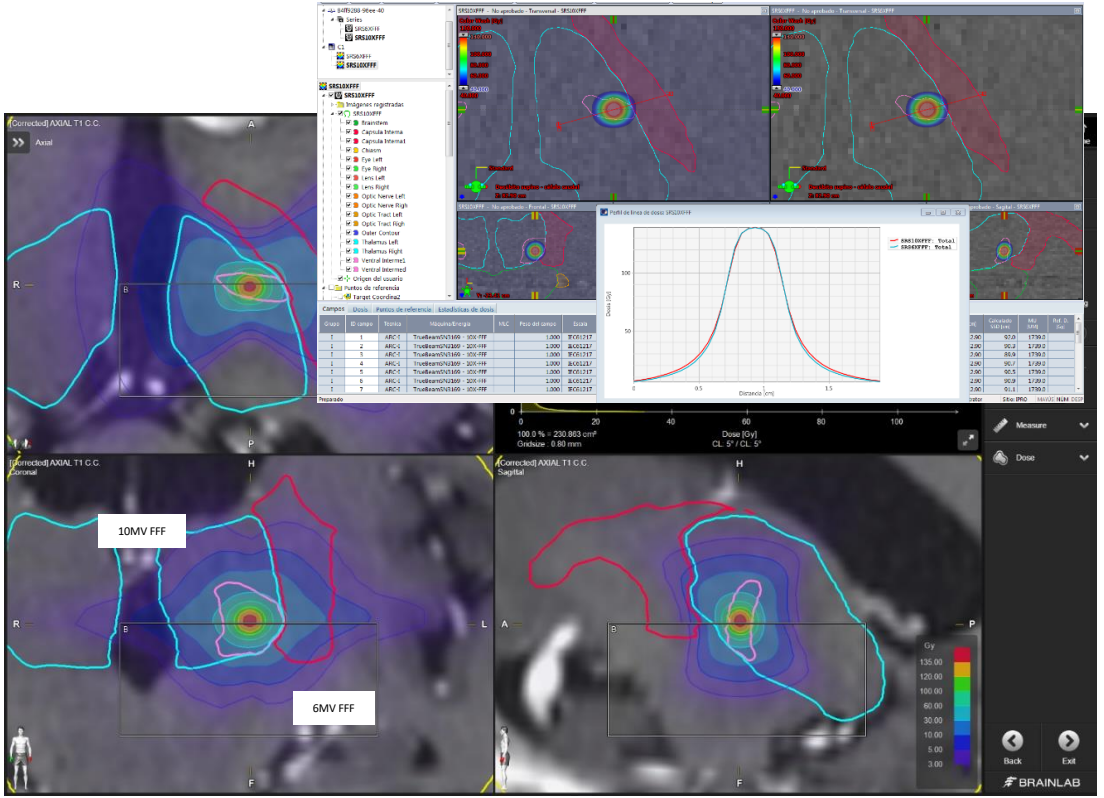
SRS Funcional LINAC - **Tremor**



- # posiciones de mesa ?
  - 6, 12 o 20 ?
  - Diferencia pude verse solo en dosis bajas
- **Energía ?**
  - 10MV FFF – 2400 MU/min
    - MU/Arc : 1775
    - Total MU : 35500
    - **Tiempo/Arc ~ 45 sec + IGRT**
  - 6MV FFF - 1400 MU/min
    - MU/Arc : 1734
    - Total MU : 34680
    - **Tiempo/Arc ~ 75 sec + IGRT**



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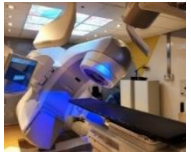
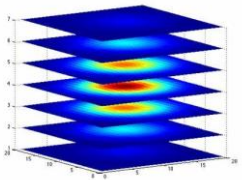
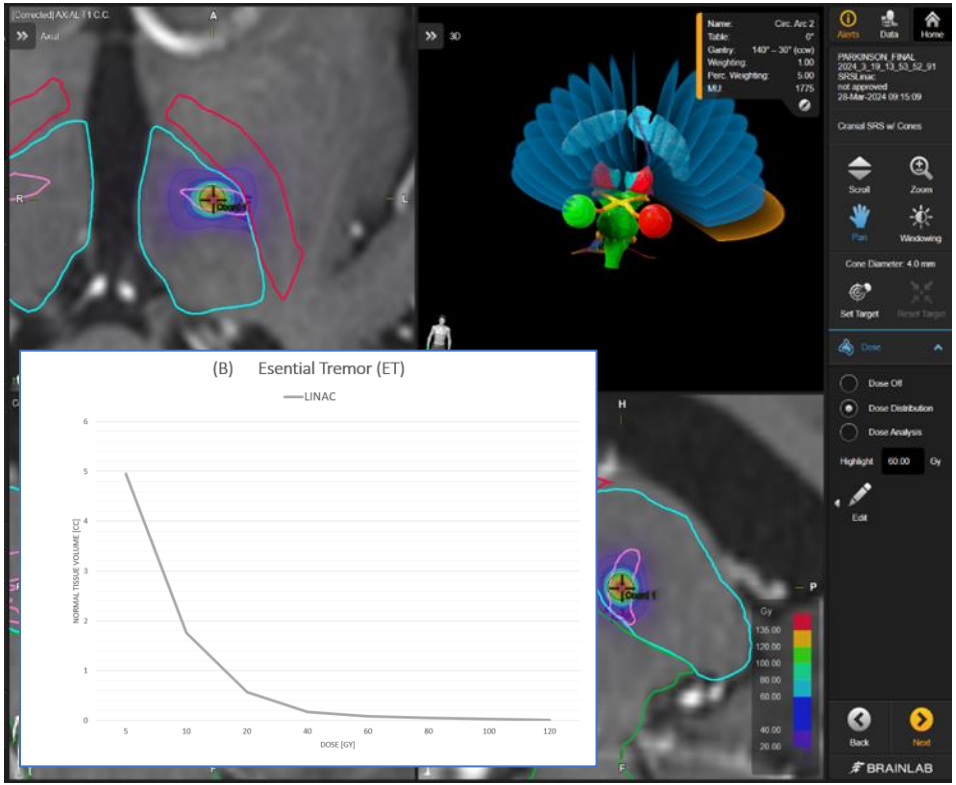
SRS Funcional LINAC - **Tremor**



- **Planificación**
  - Dosis prescripción: **140Gy** – Dmax
  - ARCOS 110°
  - Todos los arcos mismo peso
  - 20 arcos
  - Energía 10XFFF
  - HDV

ET	V5Gy [cc]	4.95
	V10Gy [cc]	1.76
	V12Gy [cc]	1.32
	V18Gy [cc]	0.67
	V50% [cc]	0.066
	GI [V35%/V70%]	3.76





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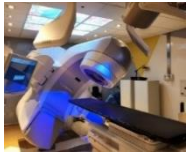
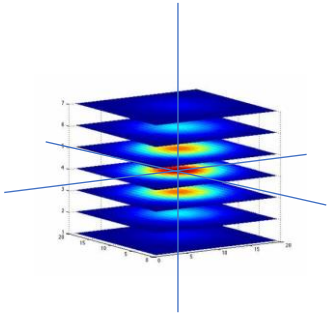
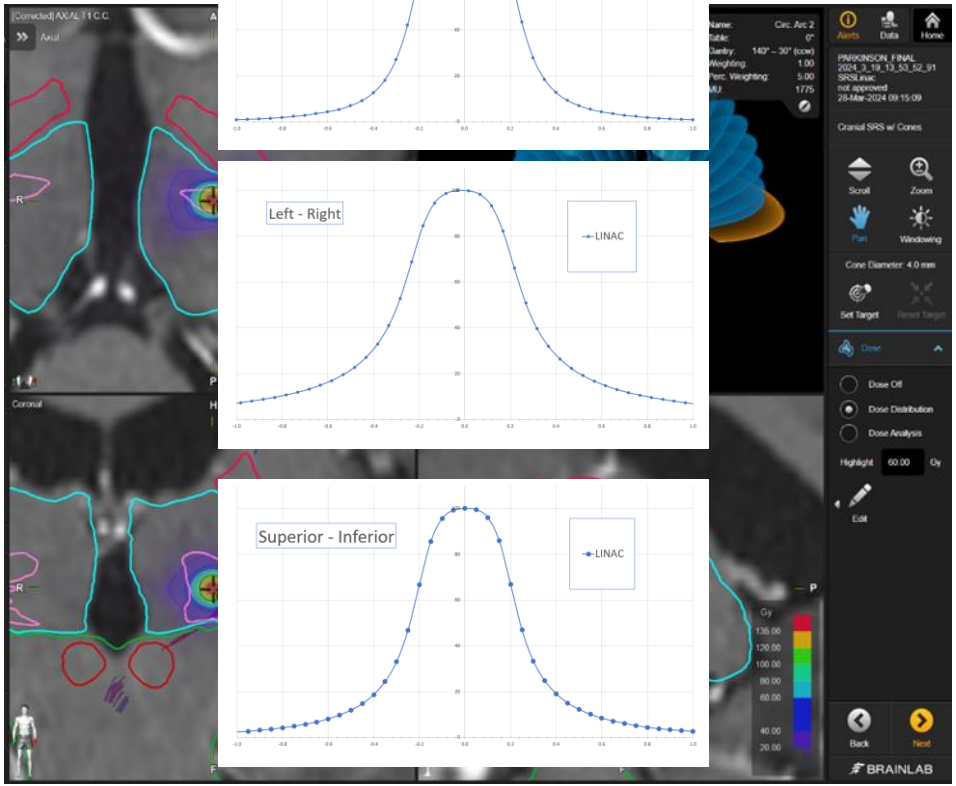
SRS Funcional LINAC - **Tremor**



- **Planificación**
  - Dosis prescripción: **140Gy** – Dmax
  - ARCOS 110°
  - Todos los arcos mismo peso
  - 20 arcos
  - Energía 10XFFF
  - HDV – FWHM / Penumbra

		LINAC	
	[cm]	FWHM	Penumbra [Left/Right]
ET	A - P	0.47	0.20/0.20
	L - R	0.57	0.35/0.35
	S - I	0.49	0.25/0.25





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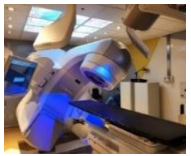
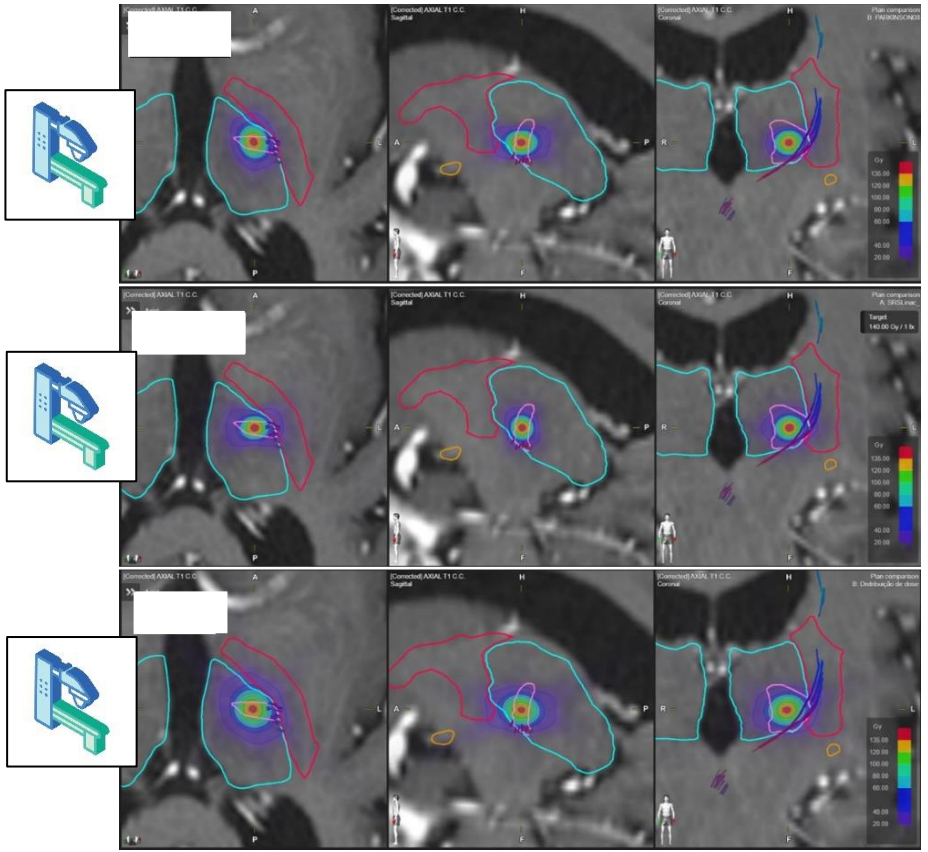
SRS Funcional LINAC - **Tremor**





- **Planificación**
  - Dosis prescripción: **140Gy** – Dmax
  - ARCOS 110°
  - Todos los arcos mismo peso
  - 20 arcos
  - Energía 10XFFF
  - HDV – FWHM / Penumbra
  - **Comparación GammaKnife - CyberKnife**

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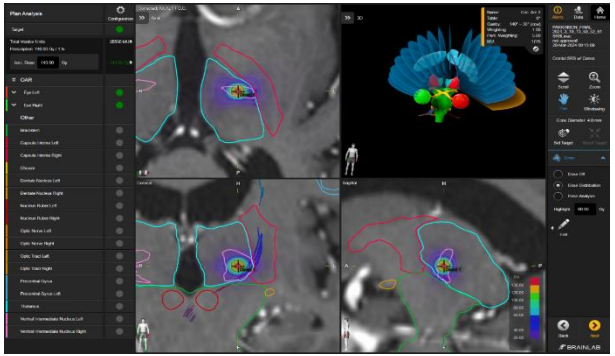
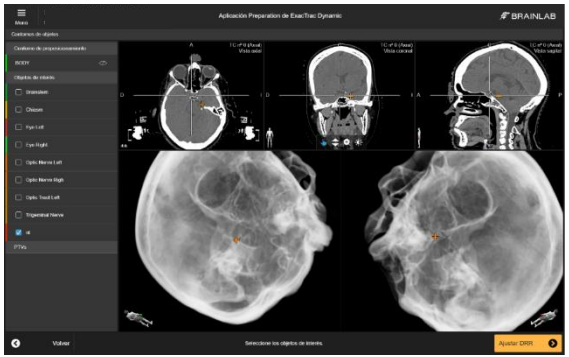
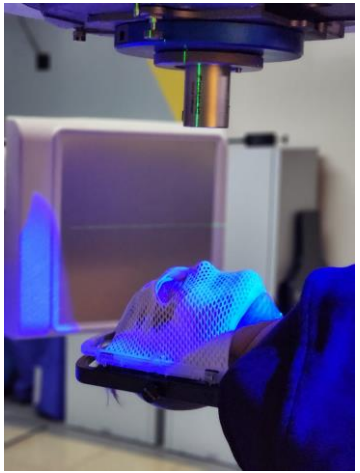
SRS Funcional Tratamiento: ETD + CBCT

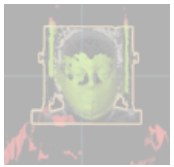


X-Ray tolerance
0.5mm / 0.5°
Camera tolerance
1mm / 1°

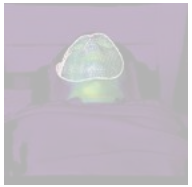




Surface guided pre-position based on CT

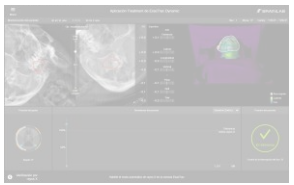


Stereoscopic X-ray fused with DRR



Auto reference surface based on actual X-ray position

CBCT position with reference surface & X-ray acquisition



Continuous surface monitoring X-ray triggered by: surface motion, MU or gantry angle

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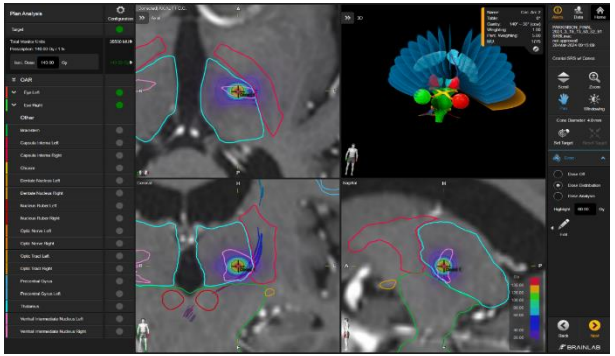
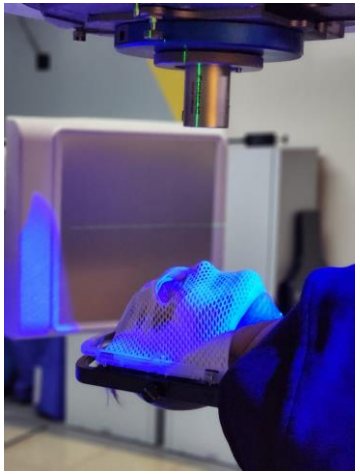
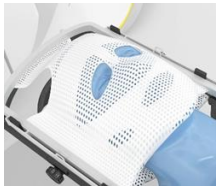
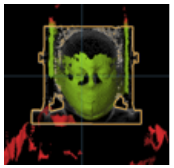
SRS Funcional Tratamiento: ETD + CBCT

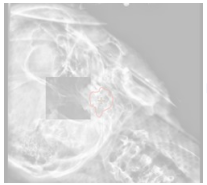




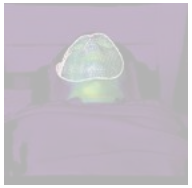




Surface guided pre-position based on CT

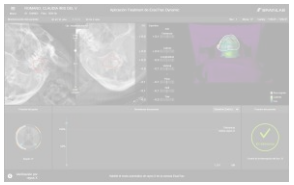


Stereoscopic X-ray fused with DRR



Auto reference surface based on actual X-ray position

CBCT position with reference surface & X-ray acquisition



Continuous surface monitoring X-ray triggered by: surface motion, MU or gantry angle

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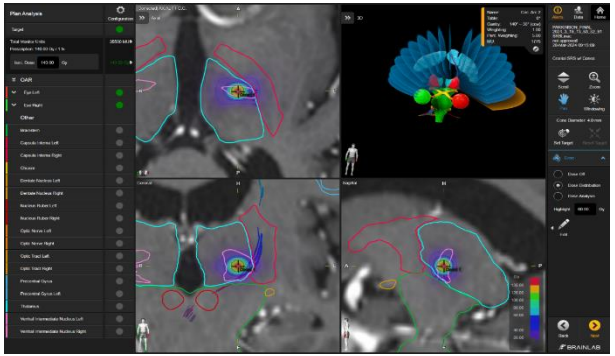
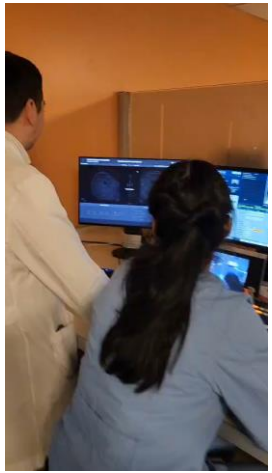
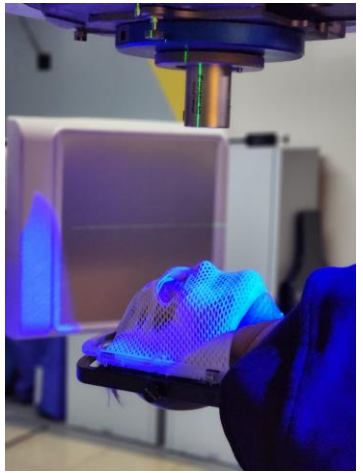
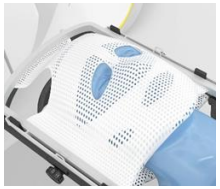
SRS Funcional Tratamiento: ETD + CBCT

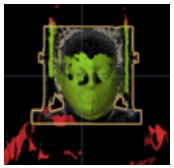


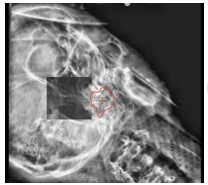




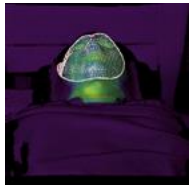


Surface guided pre-position based on CT



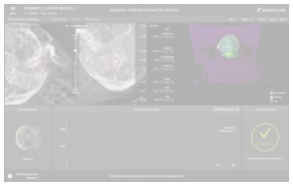


Stereoscopic X-ray fused with DRR



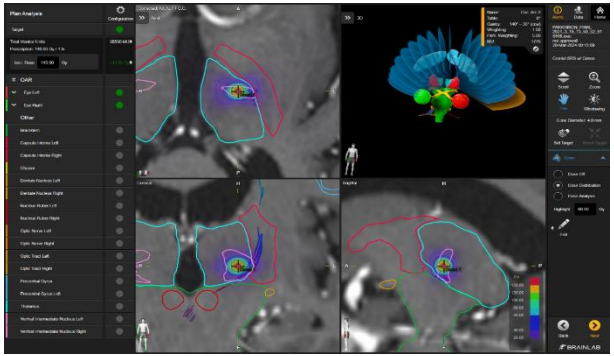
Auto reference surface based on actual X-ray position

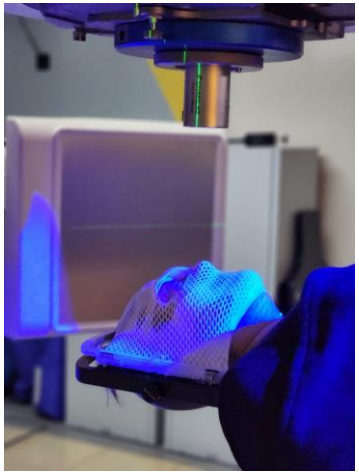
CBCT position with reference surface & X-ray acquisition

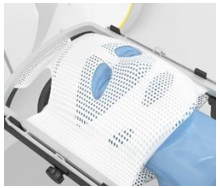


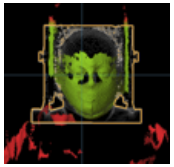
Continuous surface monitoring X-ray triggered by: surface motion, MU or gantry angle

SRS Funcional Tratamiento: ETD + CBCT

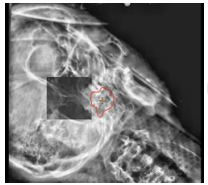




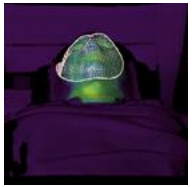




Surface guided pre-position based on CT



Stereoscopic X-ray fused with DRR



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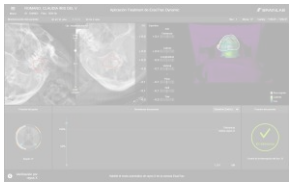
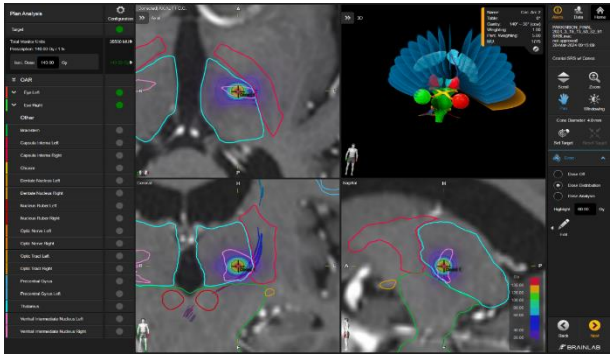
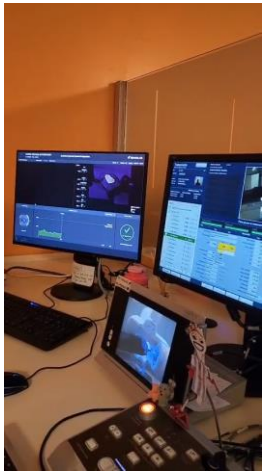
CBCT position with reference surface & X-ray acquisition

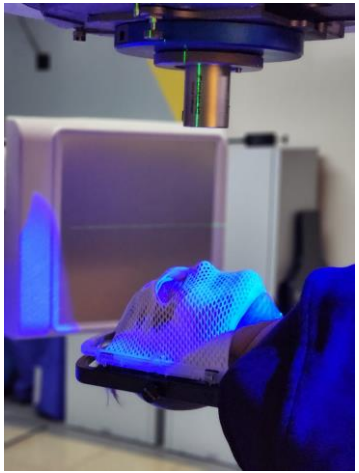


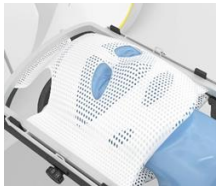
Continuous surface monitoring X-ray triggered by: surface motion, MU or gantry angle

SRS Funcional Tratamiento: ETD + CBCT

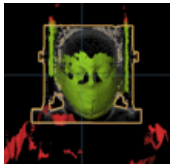


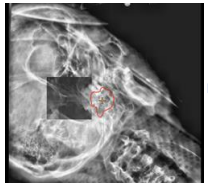




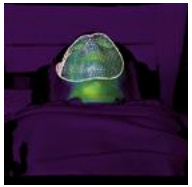


Surface guided pre-position based on CT





Stereoscopic X-ray fused with DRR



Auto reference surface based on actual X-ray position

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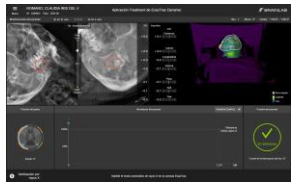


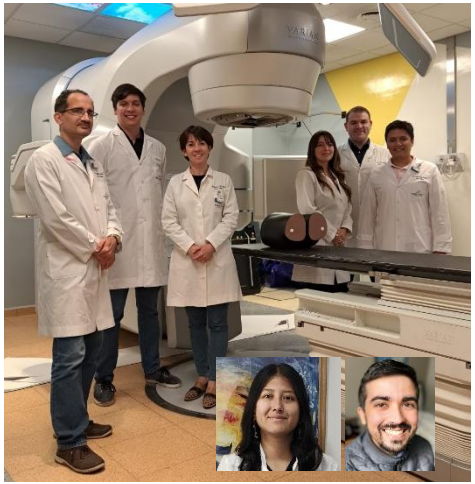
Continuous surface monitoring X-ray triggered by: surface motion, MU or gantry angle

Conclusiones

- LINAC adecuado puede ser utilizado para SRS Funcional
- SRS funcional procedimiento especial que requiere de altos estándares y workflow dedicado
- SRS funcional con LINAC debe ser analizado para cada aplicación tomando como referencia los GOLD estándares y experiencias de otras Instituciones y/o profesionales
- Una estrategia de planificación, adaptada a cada modalidad de tratamiento, es crucial para lograr resultados dosimétricos comparable al gold estandard. Sin embargo, la distribución de la dosis no es único aspecto a analizar, ya que un LINAC generalmente no es una maquina dedicada.
- IGRT intrafracción con verificación/corrección 6D de la posición del paciente es esencial y debe ser realizado de forma rápida y eficiente para cada ángulo de mesa (precisión submilimétrica)
- Por sobre todo es necesario TRABAJO EN EQUIPO

Agradecimientos

- Gabriela Reis, Ana Paula Vollet y Crystian Saraiva
- Departamento de Fisica Medica del Instituto Zunino



Muchas gracias

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