

QA TG-142 frecuencias y tolerancias en radiocirugía

Albin Ariel Garcia Andino

Física Médica

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Instituto Zunino

Fundación Marie Curie

Tecnología
e Investigación
contra el cáncer

Tecnología disponible para realizar Radiocirugía



Gamma Knife



Cyberknife



Aceleradores Lineales



Definition of Stereotactic Radiosurgery

Stereotactic Radiosurgery is a distinct discipline that utilizes externally generated ionizing radiation in certain cases to inactivate or eradicate (a) defined target(s) in the head or spine without the need to make an incision. The target is defined by high-resolution stereotactic imaging. To assure quality of patient care the procedure involves a multidisciplinary team consisting of a neurosurgeon, radiation oncologist, and medical physicist.

Stereotactic Radiosurgery (SRS) typically is performed in a single session, using a rigidly attached stereotactic guiding device, other immobilization technology and/or stereotactic image-guidance system, but can be performed in a limited number of sessions, up to a maximum of five.

Technologies that are used to perform SRS include linear accelerators, particle beam accelerators, and multisource Cobalt 60 units. In order to enhance precision, various devices may incorporate robotics and real time imaging.

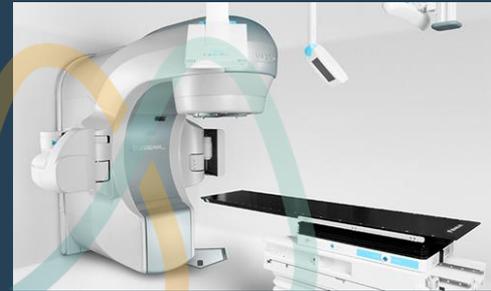
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Marco estereotáxico re-localizable



Fijación del marco



Simulación



Tratamiento

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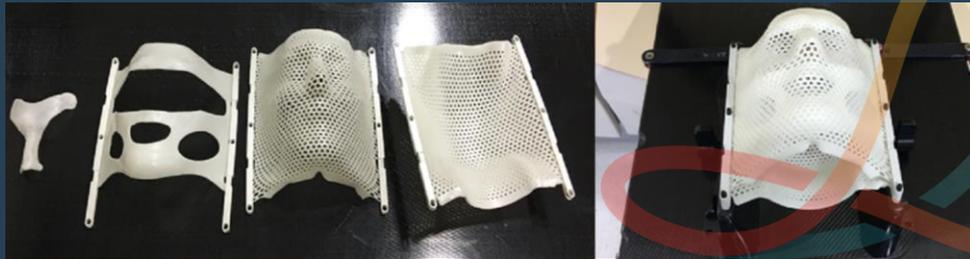
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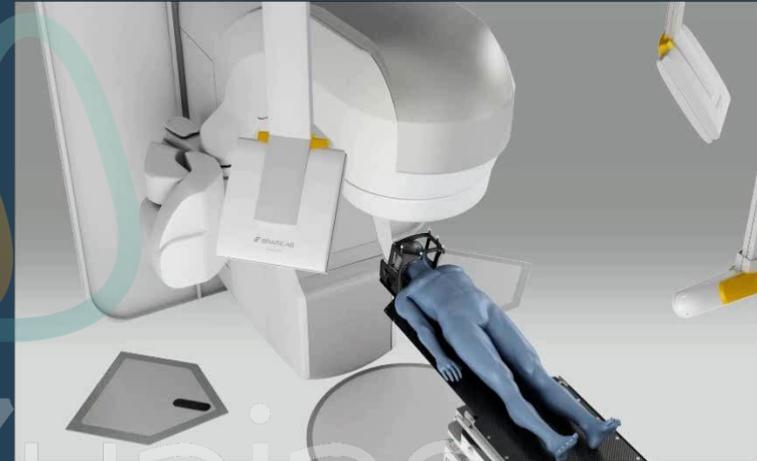
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Radiocirugía Guiada por Imágenes



Simulación



Tratamiento

Definition of Stereotactic Radiosurgery

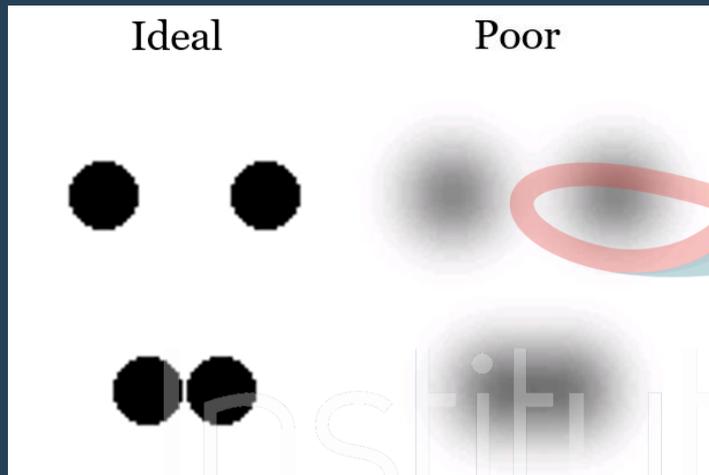
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Necesidad de control de calidad



Desafío para los FÍSICOS MÉDICOS

- alta **PRECISIÓN** y **EXACTITUD** del sistema de imágenes



!control de calidad RIGUROSO!

- continua **VERIFICACIÓN** de IGRT

Control de Calidad en Radiocirugía. Tolerancias

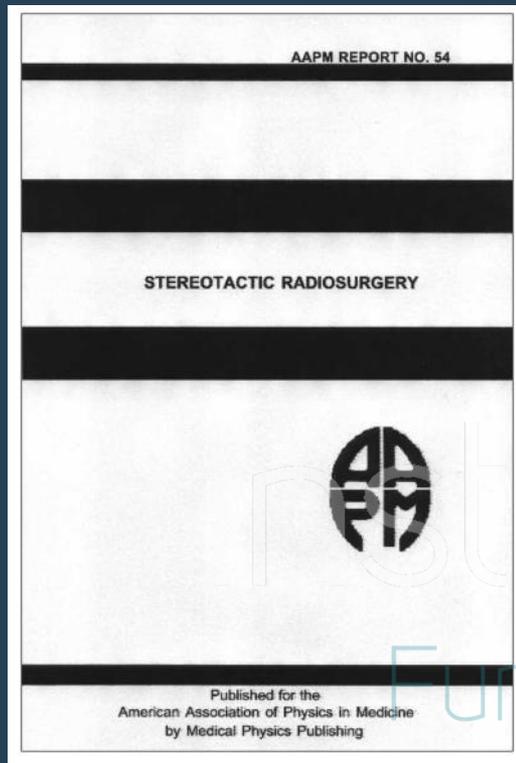
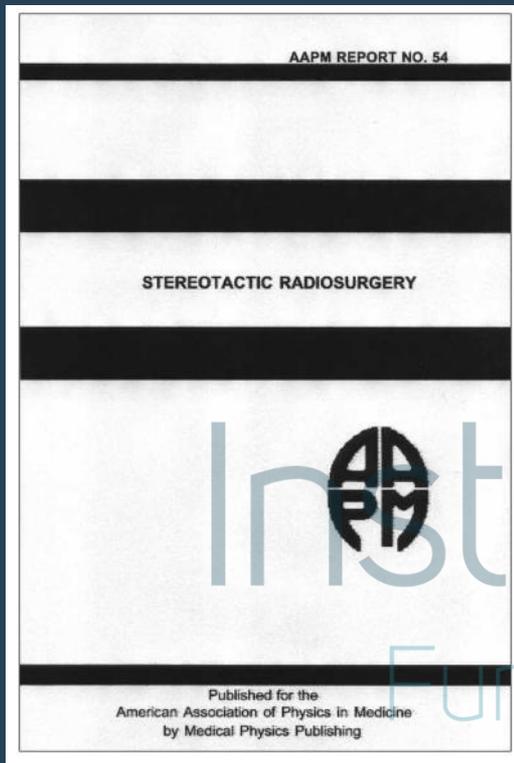


TABLE II. Achievable Uncertainties in SRS

Stereotactic Frame	1.0 mm	1.0 mm
Isocentric Alignment	1.0 mm	1.0 mm

- Invariable desde los 90's
- Característica distintiva de la radiocirugía

Control de Calidad en Radiocirugía. Tolerancias



Task Group 142 report: Quality assurance of medical accelerators^{a)}

Eric E. Klein^{b)}
Washington University, St. Louis, Missouri

The imaging devices include x-ray imaging, photon portal imaging, and cone-beam CT. The TG report was designed to account for the types of treatments delivered with the particular machine. For example, machines that are used for radiosurgery treatments or intensity-modulated radiotherapy (IMRT) require different tests and/or tolerances. There are specific recommendations for MLC quality assurance for machines performing IMRT. The report also gives recommendations as to action levels for the physicists to implement particular actions, whether they are inspection, scheduled action, or immediate and corrective action. The report is geared to be flexible for the physicist to customize the QA program depending on clinical utility. There are specific tables according to daily, monthly, and annual reviews, along with unique tables for wedge systems, MLC, and imaging checks. The report also gives specific recommendations regarding setup of a QA program by the physicist in regards to building a QA team, establishing procedures, training of personnel, documentation, and end-to-end system checks. The tabulated items of this report have been considerably expanded as compared with the original TG-40 report and the recommended tolerances accommodate differences in the intended use of the machine functionality (non-IMRT, IMRT, and stereotactic delivery). © 2009 American Association of Physicists in Medicine. [DOI: 10.1118/1.3190392]

- Invariable desde los 90's
- Característica distintiva de la radiocirugía
- Actualizadas en el TG-142

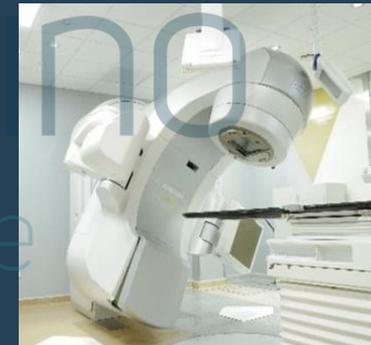
Control de Calidad para Imágenes según el TG-142

TABLE VI. Imaging.

Procedure	Application-type tolerance	
	non-SRS/SBRT	SRS/SBRT
	Daily*	
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
	Monthly	
Planar MV imaging (EPID)		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling ^b	≤2 mm	≤2 mm
Spatial resolution	Baseline ^c	Baseline
Contrast	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
Planar kV imaging^d		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling	≤2 mm	≤1 mm
Spatial resolution	Baseline	Baseline
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Contrast	Baseline	Baseline
HU constancy	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
	Annual (A)	
Planar MV imaging (EPID)		
Full range of travel SDD	±5 mm	±5 mm
Imaging dose ^e	Baseline	Baseline
Planar kV imaging		
Beam quality/energy	Baseline	Baseline
Imaging dose	Baseline	Baseline
Cone-beam CT (kV and MV)		
Imaging dose	Baseline	Baseline



Novalis Tx



TrueBeam Novalis STx

Klein, Eric E., et al. "Task Group 142 report: Quality assurance of medical accelerators a." Medical physics 36.9Part1 (2009): 4197-4212.

Control de Calidad para Imágenes según el TG-142

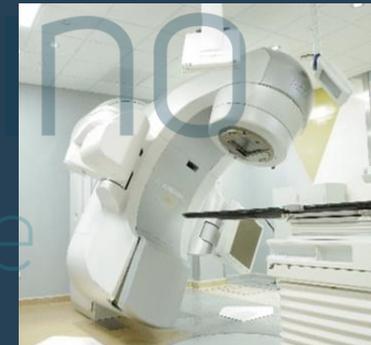
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Planar kV imaging		
Beam quality/energy	Baseline	Baseline
Imaging dose	Baseline	Baseline
Cone-beam CT (kV and MV)		
Imaging dose	Baseline	Baseline

Exactitud submilimétrica



Novalis Tx



TrueBeam Novalis STx

Klein, Eric E., et al. "Task Group 142 report: Quality assurance of medical accelerators a." Medical physics 36.9Part1 (2009): 4197-4212.

Control de Calidad según el TG-142. Pruebas diarias

TABLE VI. Imaging.

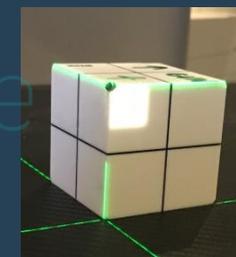
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Planar kV imaging		
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Imaging dose	Baseline	Baseline
Cone-beam CT (kV and MV)		
Imaging dose	Baseline	Baseline



Fantoma IsoCOR



ExacTrac-MV ISO coincidencia



ExacTrac posicionamiento/reposicionamiento

Klein, Eric E., et al. "Task Group 142 report: Quality assurance of medical accelerators a." Medical physics 36.9Part1 (2009): 4197-4212.

QA según el TG-142. Pruebas diarias

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Imaging dose ^e	Baseline	Baseline
Planar kV imaging		
Beam quality/energy	Baseline	Baseline
Imaging dose	Baseline	Baseline
Cone-beam CT (kV and MV)		
Imaging dose	Baseline	Baseline

<1mm



Desplazamiento [cm]

Vrt +2.50

Lng -2.53

Lat +2.52



CBCT posicionamiento/reposicionamiento

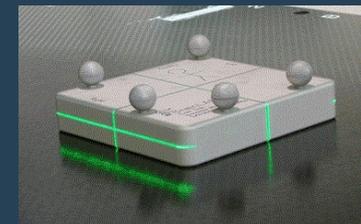
Klein, Eric E., et al. "Task Group 142 report: Quality assurance of medical accelerators a." Medical physics 36.9Part1 (2009): 4197-4212.

QA según el TG-142. Pruebas diarias

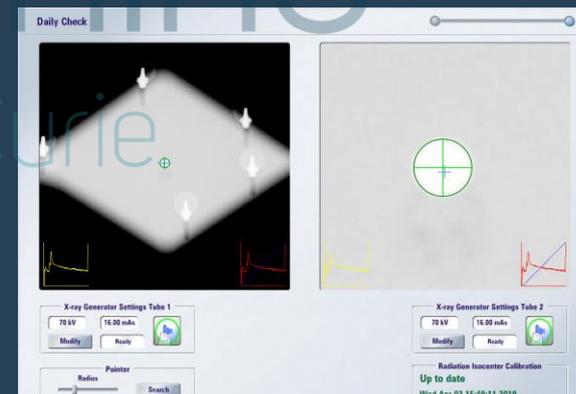
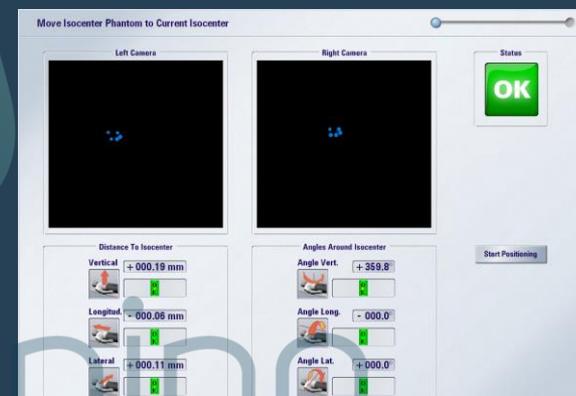
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Imaging dose	Baseline	Baseline
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Imaging dose	Baseline	Baseline

<1mm



Fantoma IR ExacTrac



Klein, Eric E., et al. "Task Group 142 report: Quality assurance of medical accelerators a." Medical physics 36.9Part1 (2009): 4197-4212.

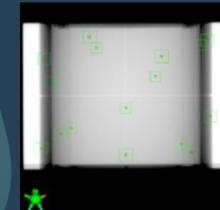
QA según el TG-142. Pruebas diarias

TABLE VI. Imaging.

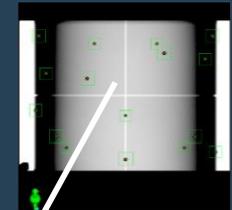
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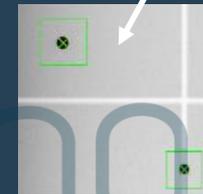
Fantoma IsoCal



MV, G 360°, C0°



kV, G 360°



<1mm
<1mm



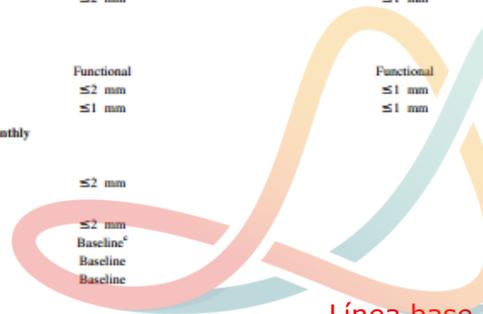
Comportamiento en el tiempo

Klein, Eric E., et al. "Task Group 142 report: Quality assurance of medical accelerators a." Medical physics 36.9Part1 (2009): 4197-4212.

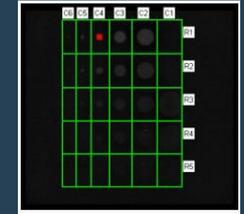
QA según el TG-142. Pruebas mensuales

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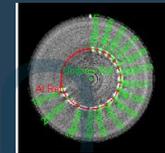
Fantoma Las Vegas



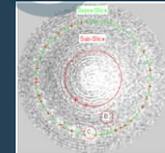
relación contraste-ruido



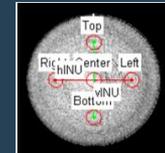
CatPhan



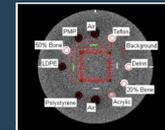
alto contraste



bajo contraste



uniformidad



constancia UH

Klein, Eric E., et al. "Task Group 142 report: Quality assurance of medical accelerators a." Medical physics 36.9Part1 (2009): 4197-4212.

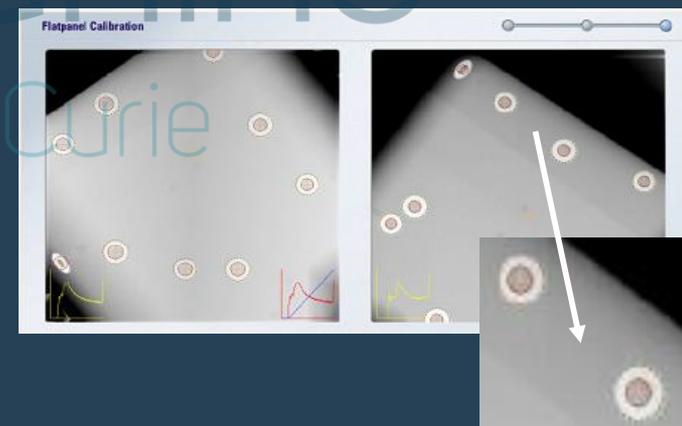
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Imaging dose	Baseline	Baseline



Fantoma Rx ExacTrac



Klein, Eric E., et al. "Task Group 142 report: Quality assurance of medical accelerators a." Medical physics 36.9Part1 (2009): 4197-4212.

QA según el TG-142. Pruebas mensuales

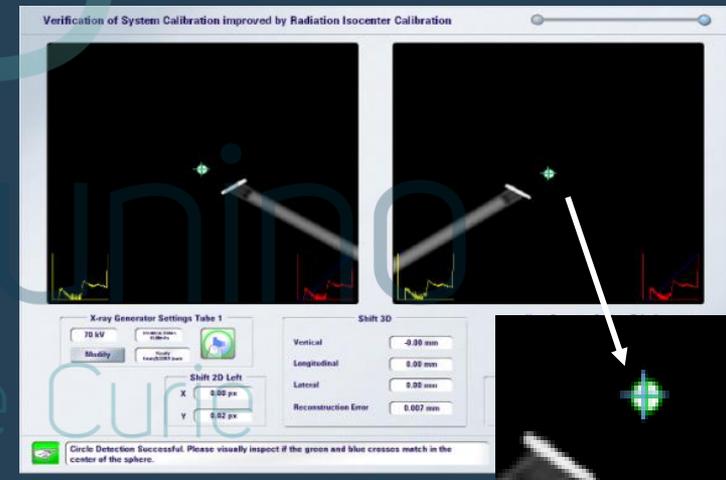
TABLE VI. Imaging.

Procedure	Application-type tolerance	
	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
	Monthly	
Planar MV imaging (EPID)		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	
Scaling ^b	≤2 mm	
Spatial resolution	Baseline ^c	
Contrast	Baseline	
Uniformity and noise	Baseline	
Planar kV imaging^d		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	
Scaling ^b	≤2 mm	
Spatial resolution	Baseline	
Contrast	Baseline	
Uniformity and noise	Baseline	
Cone-beam CT (kV and MV)		
Geometric distortion	≤2 mm	
Spatial resolution	Baseline	
Contrast	Baseline	
HU constancy	Baseline	
Uniformity and noise	Baseline	
	Annual (A)	
Planar MV imaging (EPID)		
Full range of travel SDD	±5 mm	±5 mm
Imaging dose ^e	Baseline	Baseline
Planar kV imaging		
Beam quality/energy	Baseline	Baseline
Imaging dose	Baseline	Baseline
Cone-beam CT (kV and MV)		
Imaging dose	Baseline	Baseline

<1mm



Fantoma Winston - Lutz



Klein, Eric E., et al. "Task Group 142 report: Quality assurance of medical accelerators a." Medical physics 36.9Part1 (2009): 4197-4212.

Controles complementarios

Table 1: Minimum SRS-SBRT relevant equipment QA and tolerances for C-arm linac systems.

Tolerances are absolute accuracy, not variation from baseline, unless otherwise stated

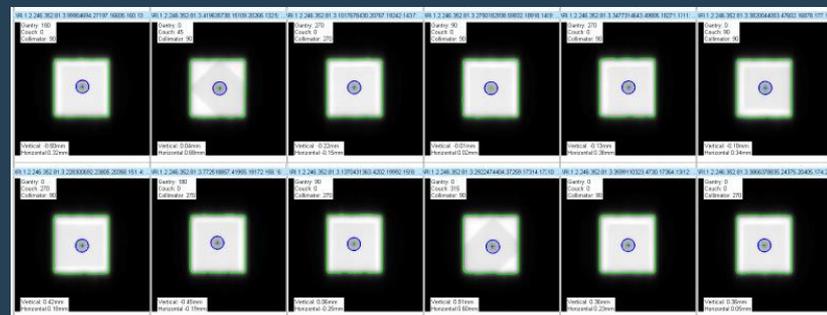
Frequency	Test	Tolerance
Semanal	Laser localization – only if using SRS techniques relying on lasers for target localization (e.g., frame based SRS without X-ray IGRT)	1 mm
	Collimator size indicator for clinically relevant aperture	2 mm total
	Radiation isocentricity test (limited gantry and couch positions) – <i>maximum deviation in center of target object relative to each projection's beam central axis</i>	1.0 mm SRS, 1.5 mm SBRT
	IGRT positioning / repositioning	1 mm SRS, 2 mm SBRT
	Imaging subsystem interlocks	Functional
	Stereotactic interlocks – cone size, backup jaws	Functional
	Accelerator output constancy	± 3%
	<u>Radiation isocentricity test – covering complete range of gantry, couch, collimator positions used clinically – maximum deviation in center of target object relative to each projection's beam central axis</u> <i>*Note: If both MLC and fixed conical collimators are used, both must be evaluated at least monthly</i>	1.0 mm SRS, 1.5 mm SBRT
	Treatment couch position indicators: relative over the maximum clinical range	1 mm / 0.5 degrees
	Output constancy at relevant dose rates	2%



Gantry	Couch	Collimator	GT (mm)	AB (mm)
180	0	90	-0.43	0.27
0	270	90	0.47	0.11
0	45	90	0.06	0.76
180	0	270	-0.38	-0.24
270	0	270	-0.15	-0.25
90	0	270	0.13	-0.15
90	0	90	0.06	0.12
0	315	90	0.89	0.59
270	0	90	-0.06	0.25
0	0	90	0.43	0.27
0	90	90	-0.22	0.41
0	0	270	0.43	0.09

Halvorsen, Per H., et al. "AAPM-RSS Medical Physics Practice Guideline 9.a. for SRS - SBRT." (2017).

ISO radiación <1mm



Controles complementarios

Table 1: Minimum SRS-SBRT relevant equipment QA and tolerances for C-arm linac systems.

Tolerances are absolute accuracy, not variation from baseline, unless otherwise stated

Frequency	Test	Tolerance
Mensual	Laser localization – only if using SRS techniques relying on lasers for target localization (e.g., frame based SRS without X-ray IGRT)	1 mm
	Collimator size indicator for clinically relevant aperture	2 mm total
	Radiation isocentricity test (limited gantry and couch positions) – <i>maximum deviation in center of target object relative to each projection's beam central axis</i>	1.0 mm SRS, 1.5 mm SBRT
	IGRT positioning / repositioning	1 mm SRS, 2 mm SBRT
	Imaging subsystem interlocks	Functional
	Stereotactic interlocks – cone size, backup jaws	Functional
	Accelerator output constancy	± 3%
	Radiation isocentricity test – covering complete range of gantry, couch, collimator positions used clinically – <i>maximum deviation in center of target object relative to each projection's beam central axis</i> <i>*Note: If both MLC and fixed conical collimators are used, both must be evaluated at least monthly</i>	1.0 mm SRS, 1.5 mm SBRT
	Treatment couch position indicators: relative over the maximum clinical range	1 mm / 0.5 degrees
	Output constancy at relevant dose rates	2%



campo luz – radiación

Halvorsen, Per H., et al. "AAPM-RSS Medical Physics Practice Guideline 9.a. for SRS - SBRT." (2017).

Distance Table

	Measured (cm)	Expected (cm)	Difference (mm)	Max. Difference Tolerance (mm)	Pass-Fail Status
Center to left side	5.02	5.00	0.20	1.00	Pass
Center to right side	4.92	5.00	-0.82	1.00	Pass
Center to top	4.91	5.00	-0.88	1.00	Pass
Center to bottom	4.98	5.00	-0.15	1.00	Pass
Horizontal Distance (Left + Right)	9.94	10.00	-0.61	2.00	Pass
Vertical Distance (Top + Bottom)	9.90	10.00	-1.04	2.00	Pass

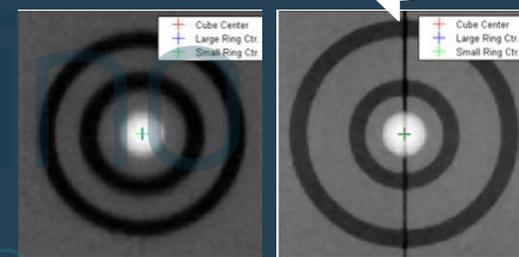
colimación <2mm

Controles complementarios

Table 1: Minimum SRS-SBRT relevant equipment QA and tolerances for C-arm linac systems.

Tolerances are absolute accuracy, not variation from baseline, unless otherwise stated

Frequency	Test	Tolerance
Mensual	Laser localization – only if using SRS techniques relying on lasers for target localization (e.g., frame based SRS without X-ray IGRT)	1 mm
	Collimator size indicator for clinically relevant aperture	2 mm total
	<u>Radiation isocentricity test (limited gantry and couch positions)</u> – maximum deviation in center of target object relative to each projection's beam central axis	1.0 mm SRS, 1.5 mm SBRT
	IGRT positioning / repositioning	1 mm SRS, 2 mm SBRT
	Imaging subsystem interlocks	Functional
	Stereotactic interlocks – cone size, backup jaws	Functional
	Accelerator output constancy	± 3%
	Radiation isocentricity test – covering complete range of gantry, couch, collimator positions used clinically – maximum deviation in center of target object relative to each projection's beam central axis <i>*Note: If both MLC and fixed conical collimators are used, both must be evaluated at least monthly</i>	1.0 mm SRS, 1.5 mm SBRT
	Treatment couch position indicators: relative over the maximum clinical range	1 mm / 0.5 degrees
	Output constancy at relevant dose rates	2%



MV

kV

Halvorsen, Per H., et al. "AAPM-RSS Medical Physics Practice Guideline 9.a. for SRS - SBRT." (2017).

Isocube Center Location

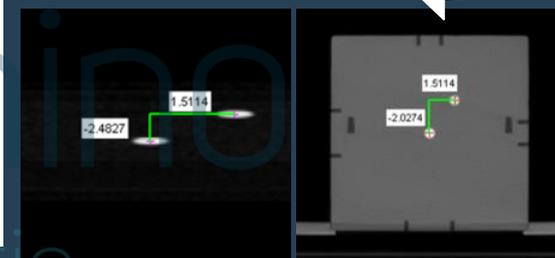
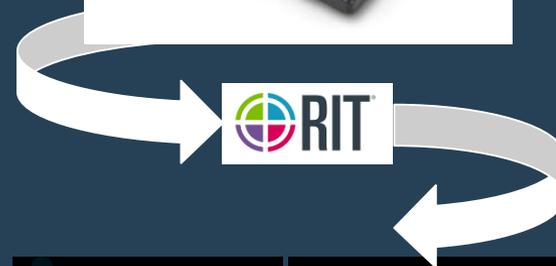
	X(mm)	Y(mm)
MV Image	0.72	-0.34
kV Image	0.76	-0.39
Offset	-0.04	0.05
Pass/Fail*	Pass	Pass

Controles complementarios

Table 1: Minimum SRS-SBRT relevant equipment QA and tolerances for C-arm linac systems.

Tolerances are absolute accuracy, not variation from baseline, unless otherwise stated

Frequency	Test	Tolerance
Mensual	Laser localization – only if using SRS techniques relying on lasers for target localization (e.g., frame based SRS without X-ray IGRT)	1 mm
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	IGRT positioning / repositioning	1 mm SRS, 2 mm SBRT
	Imaging subsystem interlocks	Functional
	Stereotactic interlocks – cone size, backup jaws	Functional
	Accelerator output constancy	± 3%
	Radiation isocentricity test – covering complete range of gantry, couch, collimator positions used clinically – <i>maximum deviation in center of target object relative to each projection's beam central axis</i> <i>*Note: If both MLC and fixed conical collimators are used, both must be evaluated at least monthly</i>	1.0 mm SRS, 1.5 mm SBRT
	Treatment couch position indicators: relative over the maximum clinical range	1 mm / 0.5 degrees
	Output constancy at relevant dose rates	2%



CBCT

Halvorsen, Per H., et al. "AAPM-RSS Medical Physics Practice Guideline 9.a. for SRS - SBRT." (2017).

Distance Table

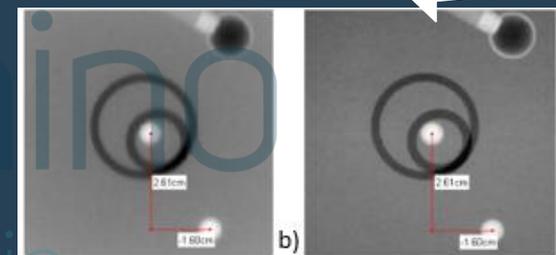
	Measured (cm)	Expected (cm)	Difference (mm)	Max. Difference Tolerance (mm)	Pass-Fail Status
Longitude	-2.47	-2.50	0.29	1.00	Pass
Vertical	-2.02	-2.00	-0.25	1.00	Pass
Lateral	1.51	1.50	0.13	1.00	Pass

Controles complementarios

Table 1: Minimum SRS-SBRT relevant equipment QA and tolerances for C-arm linac systems.

Tolerances are absolute accuracy, not variation from baseline, unless otherwise stated

Frequency	Test	Tolerance
Mensual	Laser localization – only if using SRS techniques relying on lasers for target localization (e.g., frame based SRS without X-ray IGRT)	1 mm
	Collimator size indicator for clinically relevant aperture	2 mm total
	Radiation isocentricity test (limited gantry and couch positions) – <i>maximum deviation in center of target object relative to each projection's beam central axis</i>	1.0 mm SRS, 1.5 mm SBRT
	IGRT positioning / repositioning	1 mm SRS, 2 mm SBRT
	Imaging subsystem interlocks	Functional
	Stereotactic interlocks – cone size, backup jaws	Functional
	Accelerator output constancy	± 3%
	Radiation isocentricity test – covering complete range of gantry, couch, collimator positions used clinically – <i>maximum deviation in center of target object relative to each projection's beam central axis</i> <i>*Note: If both MLC and fixed conical collimators are used, both must be evaluated at least monthly</i>	1.0 mm SRS, 1.5 mm SBRT
	<u>Treatment couch position indicators: relative over the maximum clinical range</u>	<u>1 mm / 0.5 degrees</u>
	Output constancy at relevant dose rates	2%



Halvorsen, Per H., et al. "AAPM-RSS Medical Physics Practice Guideline 9.a. for SRS - SBRT." (2017).

Image Set 3 Results

Measurement	Nominal (cm)	Value (cm)	Delta (mm)	Result
Longitudinal Distance	2.57	2.61	0.4	PASS
Lateral Distance	1.57	1.6	0.4	PASS
Vertical Distance	1.86	1.92	0.6	PASS

desplazamientos de la robótica <1mm

QA para sistemas de imágenes. Resumen

Frecuencia	Sistema de Imágenes	Procedimiento	Tolerancia (SRS/SBRT)
Diarios	ExacTrac	Verificación isocentro (infrarrojo)	OK
		Verificación módulo de Rayos-X	≤ 1.0 mm
		Verificación coincidencia de isocentros	≤ 1.0 mm
		Posicionamiento/reposicionamiento	≤ 1.0 mm
	EPID/ kV-CBCT	MPC	Funcional
Posicionamiento/reposicionamiento		≤ 1.0 mm	
Semanal	ExacTrac	N/A	-
	EPID	Resolución de contraste	visualizar agujeros (A, B, C, D, E, F)
		Prueba de Winston-Lutz	≤ 1.0 mm
	kV-CBCT	N/A	-
Mensual	ExacTrac	Calibración de isocentro (infrarrojo)	OK
		Calibración del módulo de Rayos-X	OK
		Prueba de Wiston-Lutz	≤ 1.0 mm
	EPID	Imagen de campo oscuro - ruido de imagen	$+ 400 \leq$ Valor medio $\leq 800 - \leq 10$
		Corrección de pixel	≤ 20000
	kV-CBCT	Pruebas ISO Cube - camilla 6D	≤ 1.0 mm
		Pruebas CatPhan	Línea Base
Trimestral	ExacTrac	Test End to End	≤ 1.0 mm
	EPID	Detección de objetos	Visible
	kV-CBCT	N/A	-

M u c h a s g r a c i a s



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